1963 ANNUAL REPORT

ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION
Fort Collins, Colorado
FOREST SERVICE

Raymond Price, Director
U. S. DEPARTMENT OF AGRICULTURE

PROJECT LOCATIONS

Albuquerque, New Mexico
New Federal Building

Marron Hall
University of New Mexico

Flagstaff, Arizona
Forestry Sciences Laboratory
Arizona State College

Fort Collins, Colorado
Forestry Building
Colorado State University

Laramie, Wyoming
Forest Range and Watershed Laboratory
University of Wyoming

Lincoln, Nebraska
Plant Industry Building
University of Nebraska

Rapid City, South Dakota
Forestry Sciences Laboratory
South Dakota School of Mines
and Technology

Tempe, Arizona
Agriculture Building
Arizona State University

Tucson, Arizona
Tumamoc Hill
University of Arizona

Station headquarters is at Fort Collins, Colorado,
in cooperation with Colorado State University

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March 1964

Contents

A brief summary

Forest Insect Research was directed toward ecology of several tree-killing bark beetles and defoliating insects. Results in the field of biological control were especially rewarding. A little-known predaceous clerid beetle caused the decline of a roundheaded pine beetle infestation in southern New Mexico. This prompted a study of the clerid's biology and possible methods of fostering its effectiveness in future outbreaks. Also, a Braconid wasp parasite of the spruce budworm built up in spectacular numbers in 1963 and caused a virtual collapse of the budworm population in several areas in Colorado after other factors had taken a heavy toll.

Less spectacularly, two nematode parasites of bark beetles were discovered during our research on this important group of bark beetle parasites. Several kinds of birds fed upon the Black Hills beetles during the beetle flight period, and took about 10 percent of them. A polyhedrosis virus disease and starvation played an important part in population changes in the Great Basin tent caterpillar in northern New Mexico.

Low survival of overwintering populations of two important species of Ips in pine in the Southwest prompted a study of the effects of low temperatures. It was found that Ips lecontei is killed by temperatures around 5°F. and I. confusus around 0°F.

The puzzle of how the Black Hills beetle aggregates in specific trees was partially solved by caging beetles on trees. It was found that beetles were attracted only to those trees with female beetles.

Forest Disease Research began basic studies on a variety of tree disease problems, but continued major emphasis on dwarfmistletoes. Field and herbarium studies of these parasites revealed there are two species on hard pines in southern Arizona: the well-known southwestern ponderosa pine dwarfmistletoe and a previously undescribed species that attacks only Chihuahua pine. Another study in Arizona revealed that dwarfmistletoe-infected ponderosa pine stands on the plateau adjacent to the south rim of the Grand Canyon show a definite but as yet unexplained association with the rim of the canyon. In Colorado, the flowering periods of dwarfmistletoe in the Roosevelt National Forest were determined from pollen counts. Lodgepole pine dwarfmistletoe starts blooming about a month earlier than ponderosa pine dwarfmistletoe, and reaches peak pollen production about a month and a half earlier. The most gratifying accomplishment in dwarfmistletoe research was the successful photography of seed expulsion at a speed of 1/200,000th of a second.

Eleven genera of plant-parasitic nematodes were recovered from forest and woodland soils of New Mexico in the first steps of a study to determine the role of nematodes in the decline and mortality of marginal ponderosa pine and associated species after prolonged drought. At Bessey Nursery in Nebraska, it was found that either Dowfume MC-2 or Vapam gave good control of root-lesion nematodes that attack eastern redcedar, Rocky Mountain juniper, white spruce, and blue spruce nursery stock. In other tests, several fungicides were effective against leafspot of buffaloberry and skunkbush sumac.

Timber Management Research emphasized forest reproduction and growth. Clear cutting is recommended for harvesting lodgepole pine, since heavy partial cutting neither increased growth nor decreased mortality in old-growth stands. In a corollary study, satisfactory numbers of new seedlings became established after both heavy partial cutting and commercial clear-cutting.

Ponderosa pine transplants grew better when planted to the same depth as they grew in the nursery than when deep-planted with only the terminal buds exposed. Also, residuals of herbicides used to deaden herbaceous vegetation had no discernible effect on the survival and growth of ponderosa pine seedlings.

Cutting rows of trees adjacent to hardwoods and softwoods in crowded windbreaks accelerated the growth and increased the effectiveness of both as windbreak trees. Crown density increased after release, and sprouts on the boles and stumps of hardwoods increased windbreak density near the ground.

Forest Fire Research continued to emphasize the use of fire in land management. Similar patterns of fire behavior can be expected in ponderosa pine, even when the treated areas differ greatly in size, if burning conditions are similar. Desiccation of chaparral with herbicides may decrease one aspect of flammability through reduction of waxes, fats, and oils.

The field of Forest Products was typified by increased concern in all areas of cost, and in the marked shift to a more diversified type of production. Reduced profit ratios, especially in the lower grades of lumber, required much closer agreement between predicted and actual production cost factors. This situation brought with it a much greater concern about the reliability of timber volume estimates, along with the predicted lumber quality recovery.

Closely coupled to the interest displayed in reducing production costs was the increase in interest in products other than boards. A number of mills changed to the production of dimension items, and several more are in the process. Interest in panel-type products also appears to be at an all-time high.

Forest Recreation Research explored the use of 12 existing recreation sites by summer recreationists for camping and day use. Factors associated with the choice of family units appear to be distances from parking, toilets, drinking water, fishing point, and other units, and size of clearing at the unit.

Range Management and Wildlife Habitat Research was expanded to include investigation of prairie grouse habitat in the Great Plains. Also started were a study of sheep management on alpine-subalpine ranges in Wyoming and studies to determine the feasibility of using pelleted seed in range revegetation. As a step toward learning more about nutritive values of livestock and game forage, analytical equipment was added at the Station's laboratory in Rapid City, South Dakota.

Among current findings, utilization of 65 to 70 percent of crested wheatgrass herbage in northern New Mexico during spring months resulted in stand maintenance and satisfactory cattle weight gains. Rotation grazing at a moderate rate of stocking appears to be superior, as a range management method, to seasonlong grazing at the same rate on mountain grassland range in the Bighorn mountains of Wyoming. On the other hand, both were superior to rotation grazing where much heavier stocking was used. Growth of seeded big bluegrass far exceeded that of crested wheatgrass and Russian wildrye during severe drought in Colorado, emphasizing its usefulness and value for revegetating deteriorated pine-bunchgrass ranges.

Wide-spread mortality of willows in the Black Hills was found to be confined mainly to 2 of the 20 species that grow there. Attention is now being focused on these two to determine the cause of mortality. In Arizona, whitetail deer were attracted to and made heavy use of succulent sprouts of shrubs that developed after controlled strip burning in dense chaparral. Recently acquired knowledge of habitat perference of deer and elk on pinyon-juniper rangeland in New Mexico is providing a basis for planning range improvement practices that should benefit both ranchers and hunters.

Watershed Management Research continued to emphasize studies in water yield improvement and soil stabilization. Removal of all timber from streambottoms and adjacent moist sites on a watershed in the pine-fir type in Arizona increased streamflow about 50 percent.

Areas in Wyoming covered with big sagebrush accumulated more snow than comparable grasslands. In the grassland areas, continuous sheets of ice were present in the snowpack, while no evidence of this condition occurred in the sagebrush cover type.

Water vapor is lost from throughout the snowpack during March at 9,500 feet in the Colorado Rockies. Total loss from the pack amounted to 0.1 inch per day for clear days during this early spring period.

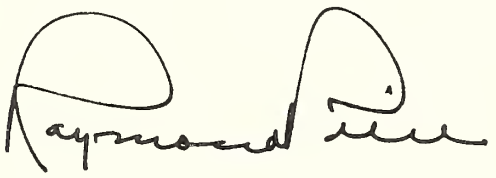
Shrub live oak, a major component of Arizona chaparral, is receiving major emphasis in a series of studies designed to understand the role of chaparral in watershed management. This species of oak has limited use for forage. In selected areas, conversion of chaparral to plants of more economic value seems to increase both water yield and usable forage. Effective chemical controls for this oak are being studied.

Increased water yield resulting from the conversion of chaparral to grass in Arizona can offset the initial cost of treatment in about 30 years. This analysis includes the cost of spraying to control regrowth, but does not include the cost of grass seeding or the benefits in increased forage production.

Improving ground cover through controlled grazing effectively reduces erosion on the badlands of the Rio Puerco in New Mexico. Subsoil ripping on the sparsely vegetated, shale-derived soils of the Rio Puerco is also effective in reducing runoff and erosion. However increased soil piping may occur if the shale parent material is within reach of the mechanical treatment (approximately 30 inches).

A prefabricated concrete check dam for gully control has been designed and is now being tested in the field.

Details of these and other findings are presented in the following pages. Complete accounts of our research are released through various publications. An annotated list of publications issued in 1963 is included in the bibliography at the end of this report.



Raymond Price, Director

Two new research facilities were completed at field locations during 1963. The Forest Range and Watershed Laboratory (above) is on the University of Wyoming campus in Laramie. The Forestry Sciences Laboratory (below) at Flagstaff, Arizona, is on the campus of Arizona State College. Both laboratories were dedicated in May.

Forest Insect Research

Black Hills beetles attracted by attacking female beetles

Female Black Hills beetles (Dendroctonus ponderosae Hopk.) attacking healthy ponderosa pines (Pinus ponderosa Lawson) where they were caged (fig. I-1) definitely attracted other beetles. Laboratory-reared beetles were placed in the cages just prior to the natural flight of beetles. Cages were installed on 15 trees randomly distributed at least 200 feet apart in a natural infestation, and no closer than 250 feet to trees from which the field population would emerge. Eighty-four males were placed in each of five cages, 84 females in five cages, and 84 pairs in five cages. The results: None of the trees with the caged males became infested; four of the five trees with females became infested as well as four to eight trees adjacent to each of the trees with cages; and four of the five trees with pairs became infested as well as four to six adjacent trees around each.

Figure I-1.--A ponderosa pine with a 4-square-foot wire screen cage. Black Hills beetles were placed in the cage to test attraction of wild beetles to the tree.

Future studies will be directed to learning more about the nature of the attractant and how it may be used in developing new control methods.

Several kinds of birds eat Black Hills beetles

During the period between emergence and entrance into new trees to lay their eggs--often referred to as the flight period--the Black Hills beetle numbers are often reduced by unknown factors. Birds were found to take about 10 percent or more of the beetles during the flight.

To learn something about the kinds and numbers, the birds were counted in one infestation and stomach contents from birds in a similar nearby infestation were analyzed for Black Hills beetles. Numbers of beetles were estimated in each infestation. A reliable figure on the number of beetles eaten by birds could not be established because of the wide variation in the number of beetles per stomach between individual birds within each species. For example, seven white-breasted nuthatches (Sitta carolinensis Latham) were taken, but the stomachs of only two contained Black Hills beetles; contents of one consisted of 95 percent Black Hills beetles, the other 70 percent. Other birds that fed upon the beetles in significant quantities were pigmy nuthatch (Sitta pygmaea Vigors), western wood pewee (Contopus sordidulus Sclater), and an Empidonax flycatcher. Traces of beetles were found in several other species.

No species appeared to depend upon the beetle as the primary source of food, nor did the birds appear to be attracted into the area because of the beetles. The beetle flight occurs in August, after the general nesting season.

Techniques for rearing Black Hills beetle

A search is continuing for a method of rearing large numbers of Black Hills beetles needed for studies. Environment tests on freshly cut bolts of ponderosa pine infested with beetles demonstrated that an environment maintained at 70°F. and 80 percent relative humidity was better than 60°F. and 80°F. At 70°F., bolts infested with 2.5 pairs of parent beetles per square foot of bark produced 33 new adults per square foot. The progeny, however, were 10 percent smaller than their parents and fewer in number than expected under natural conditions.

Clerid beetle is important predator of roundheaded pine beetle

A predator, Enocleris sp., (fig. I-2) has played an important role in the decline of a 4-year-old infestation of the roundheaded pine beetle, (Dendroctonus convexifrons Hopk.) in ponderosa pine in southern New Mexico. Only 17 bark beetles per square foot of bark survived to the adult stage in late August--substantially less than the number of parent beetles in the same bark area. Much of the mortality came during May and June, when there were 14.7 clerid larvae per square foot of bark.

Figure I-2.--A clerid beetle was found to be the most important insect predator of the roundheaded pine beetle, a tree-killing bark beetle.

Adults of the clerid beetle, about one-half inch long, may be seen busily crawling and laying eggs on the bark of infested trees in late April and early May.

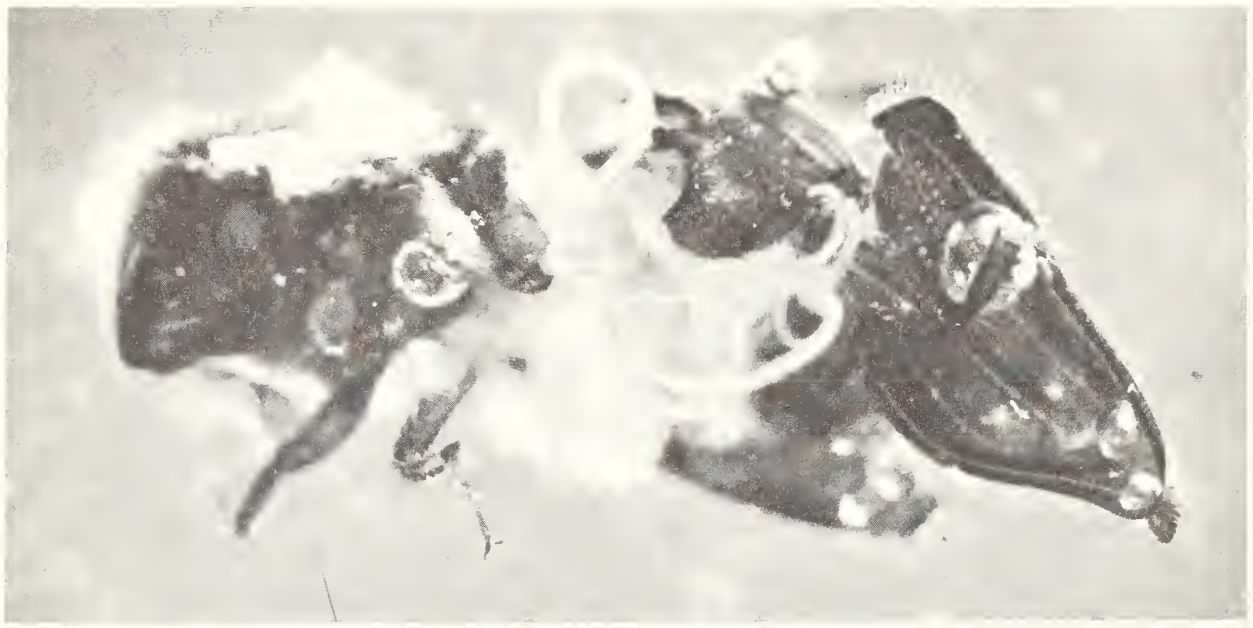


Figure I-3.--A crushed bark beetle shows several adult nematode parasites.

Two new nematode parasites discovered

Two new species of parasitic nematodes were found on the roundheaded pine beetle, a bark beetle pest of ponderosa pine. Parasitaphelenchus (new species) is found both as a parasitic form in the body cavity of the insect and as a free-living form in the bark beetle galleries. The young are produced in the insect galleries and later invade the insect larvae. The new species of Parasitylenchus is one of several in this genus that are parasitic on bark beetles. The wormlike nematodes produce young in the body cavity of the adult beetles. The young emerge at the time the female beetle lays her eggs beneath the bark. There the female nematode is fertilized and enters a new host. Development of the female continues inside the insect, reaching the adult stage simultaneously with adult stage of the bark beetle (fig. I-3).

The clerid larvae are mature by mid-July after having fed on an as yet unknown number of roundheaded pine beetle larvae beneath the bark.

At maturity, they migrate to the base of the tree and construct cells in the outer bark to pupate.

Two species of Ips in Southwest relatively non-cold hardy

Outbreaks of two bark beetles, Ips lecontei Swaine, on ponderosa pine in south-central Arizona and Ips confusus (Leconte) on pinyon (Pinus edulis Engelm.) in Arizona and New Mexico, often build up with the summer generations and kill many trees. Both species overwinter in the adult stage. Mortality of adults during the past winter was observed to be very high, low temperatures were suspected. Laboratory studies confirmed the suspicion. Both species were found to be less cold hardy than many other bark beetles. When the beetles were removed from the bark and exposed to controlled low temperatures for 3 hours, up to 100 percent of Ips lecontei were killed at 5° F.; up to 100 percent of Ips confusus were killed at 0° F.

Under natural conditions, the bark and wood provide some insulation and protection from low air temperatures. The amount of protection varies with duration of the lethal temperatures, bark thickness, and tree diameter. For example, a recorded low temperature of -5° F. in an Ips lecontei outbreak resulted in mortalities of 8 percent in tree stems 10 to 12 inches in diameter to 93 percent in stems less than 3 inches in diameter. A field temperature of -16° F. in an Ips confusus outbreak killed 20 to 100 percent of the adults.

With this information, mortality of the overwintering generations and the infestation trend can be predicted by using temperatures recorded at weather stations. The results also show that the opportune time for control of these two beetles is against the spring generation when the beetles are at their lowest numbers.

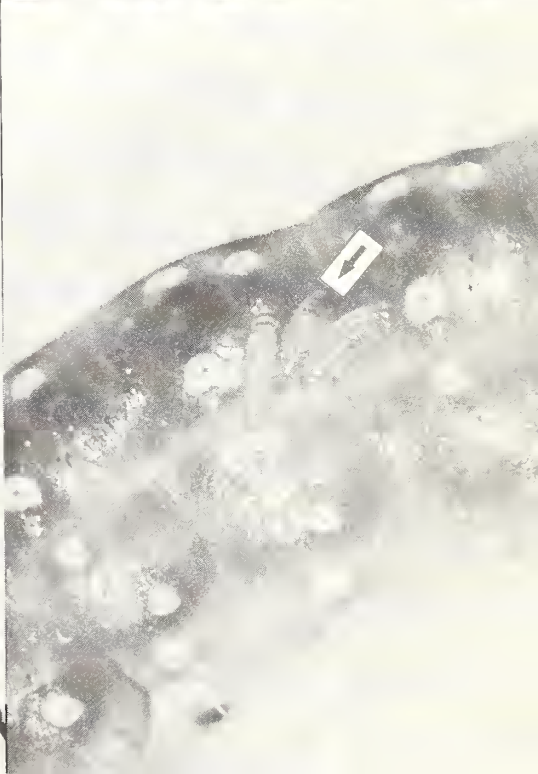
Natural factors diminish spruce budworm outbreaks in Colorado

The spruce budworm, Choristoneura fumiferana (Clem.), epidemic for 10 years exhibited the long-awaited sudden decline in most areas of Colorado. Gross infested acres dropped from 625,000 acres in 1962 to 47,000 acres in 1963. The insect has caused widespread damage to Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco), the true firs (Abies spp.), and spruce (Picea spp.).

The causes of the decline were, as usual, elusive. We do know that: (a) Trees badly weakened by the budworm produced little new growth, the preferred food; (b) insect parasites were active in 1962 and even more abundant in 1963; (c) egg deposition was greatly reduced in 1962 compared to previous years; (d) a fungus, Beauvaria, probably bassiana, was found on hibernacula collected from two locations in southern Colorado; and (e) an external parasite, Bracon politiventris (Cush.), (fig. I-4) showed spectacular increases in some areas in 1963.

Other important parasites of budworm larvae include Glypta fumiferanae (Vier.) and Apanteles fumiferanae Vier. (Hymenoptera). Important parasites of budworm pupae are Phaeogenes hariolus (Cress.) (Hymenoptera) and Ceromasia auricaudata Tris. (Diptera).

Figure I-4.--Three tiny Bracon politiventris (Cush.) larvae (arrow) feeding on a paralyzed full-grown spruce budworm larva. This tiny wasp (smaller than a mosquito) was an important budworm parasite in some areas where budworm populations were much reduced in 1963.



Mobile laboratory ideal for spruce budworm research

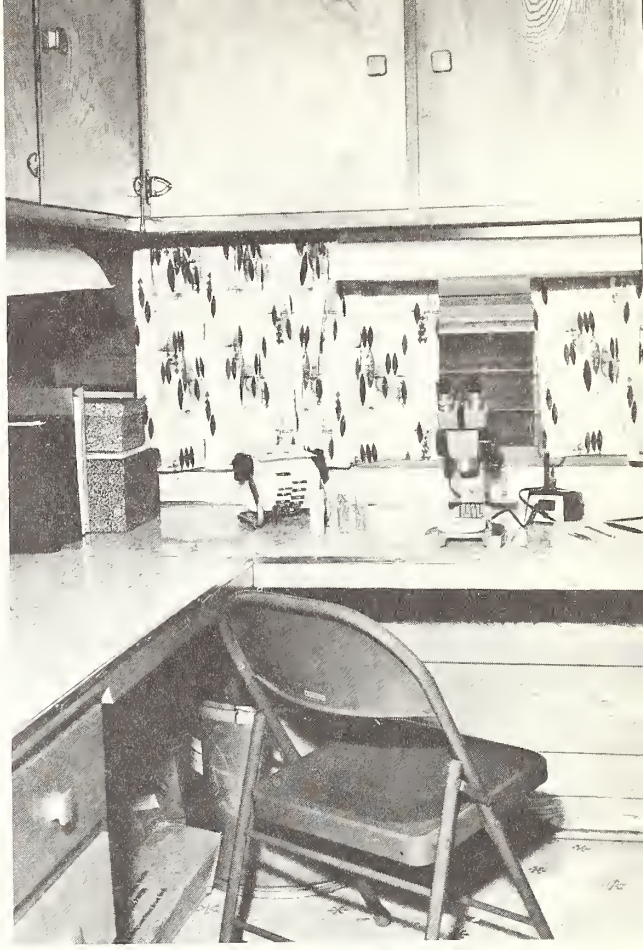
The study of natural mortality factors occurring in forest insect populations requires research workers to operate close to infestations (fig. I-5). A small trailer was used successfully for spruce budworm research in 1963.

Relatively uniform temperatures are maintained in a 7- by 9-foot rearing room by a thermostat-controlled overhead evaporative cooler and two electric heaters. Humidity is provided by a small humidistat-controlled cooler. The 7- by 10-foot laboratory at the front of the trailer is well lighted and provides ample space for microscope work, media preparation, foliage examination, and storage.

Figure I-5.--A trailer house designed as a traveling laboratory, served as headquarters for on-the-ground research in spruce budworm infestations in 1963.

Pairs of budworm moths are caged in pint ice-cream cartons for reproduction trials.

The 7- by 22-foot mobile laboratory is easily hauled and maneuvered by a pickup truck as needed to be near spruce budworm infestations.



Bench-space in the front laboratory is sufficient for two workers.

Spruce budworm larvae are collected in the field and reared in muslin-bottomed trays for parasite recovery.

Budworm pupae are held in plastic vials on racks for parasite emergence.

Virus and starvation affect Great Basin tent caterpillar

Epidemic populations of the Great Basin tent caterpillar, Malacosoma fragile Stretch, continue to cause aspen (Populus tremuloides Michx.) defoliation and mortality in northern New Mexico. Observations and measurements of egg mass densities, caterpillar abundance, and biological control factors in six plots the past 4 years are showing some interesting but as yet inconclusive results.

Three consecutive years of complete defoliation on three plots have top killed most of the trees. Few live branches remain for foliage production in 1964. Two of these three plots showed a sharp decline in egg mass counts in 1963 due to almost 100 percent starvation of the larvae. A native polyhedrosis virus disease is present in all of the plots, and is also playing a most important role in population fluctuations. Several more years of observations are needed to determine the pattern of action.

Average egg mass densities of one egg mass or less on two 30-inch branches taken from the upper crown may result in light defoliation; three or more in complete defoliation. Equally, if not more closely, associated with the amount of defoliation, however, may be the abundance and action of the virus disease and a decrease in the amount and quality of foliage caused by defoliation the preceding years.

Safer insecticide evaluated

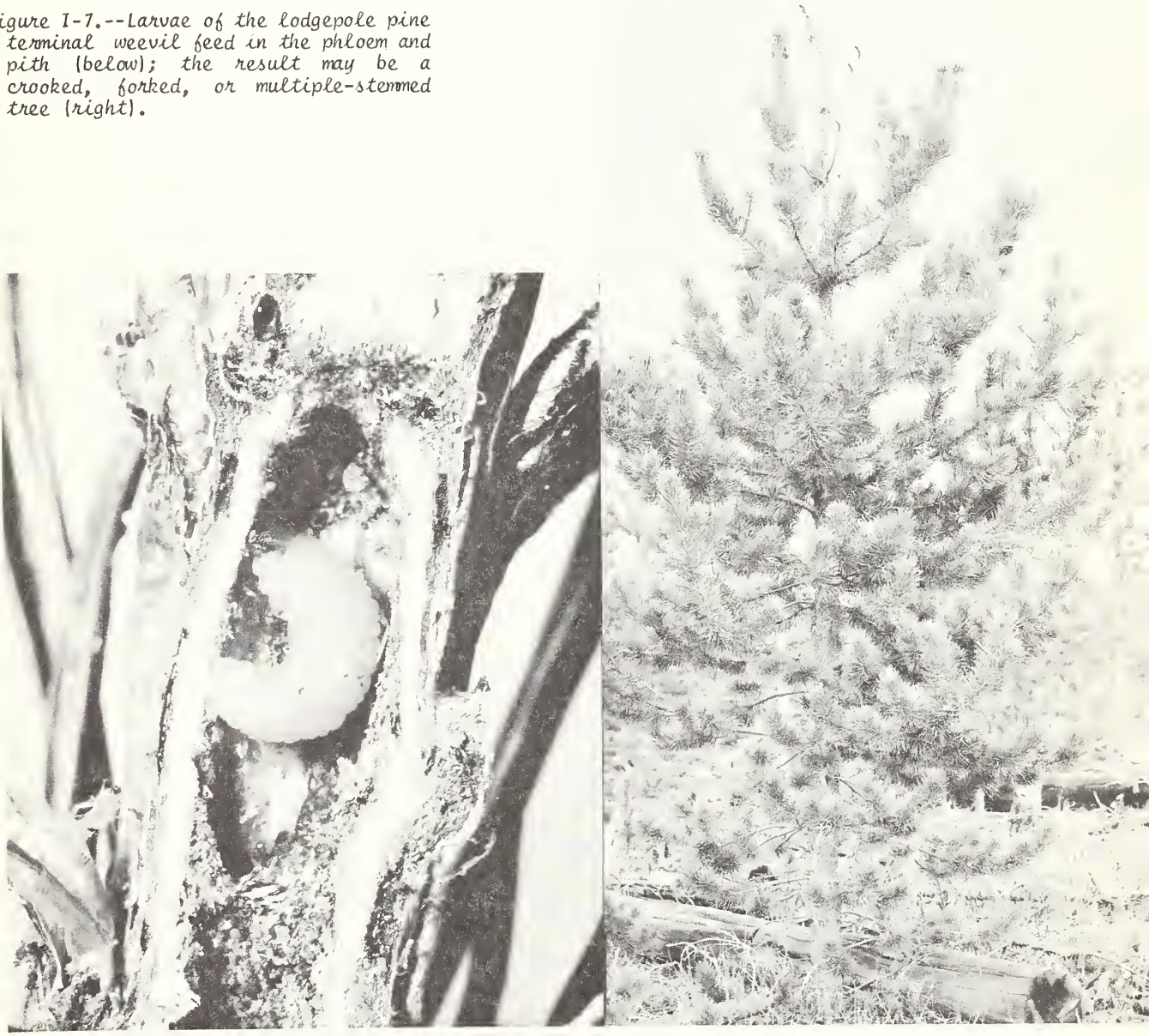
The search for safer insecticides for use in large-scale control projects has prompted evaluation of new chemicals. Dimethoate, which has a lower toxicity to fish, wildlife, and man, was tested against the spruce budworm on the Carson National Forest, New Mexico. Dosages of 4 and 8 ounces of actual dimethoate were applied in 1 gallon of water per acre by helicopter (fig. I-6). Both dosages were equally effective against fifth-instar budworm larvae. Budworm mortality averaged about 85 percent, and varied from 50 to 100 percent on individual plots. The same dosages applied to the earlier bud-mining stages of the insect were not effective. Dimethoate needs further testing on an operational basis before it can be recommended for large-scale use.

Figure I-6.--An insecticide with low toxicity to fish, wildlife, and man is sprayed from a helicopter in a test against the spruce budworm.

Lodgepole pine terminal weevil a serious pest

The lodgepole pine terminal weevil, (Pissodes terminalis Hopp.), a native insect, has become a serious pest of advanced lodgepole pine reproduction and small sapling stands. Seriousness of the problem will increase as more lodgepole pine stands are cut and the reproduction reaches the susceptible age. In one stand on the Routt National Forest, Colorado, more than 40 percent of the small saplings have been injured. The weevil lays its eggs in the extending shoot; the larvae then feed in the phloem and pith (fig. I-7). The injury may result in a crooked, forked, or multiple-stemmed tree. Injury to pole stands is not serious.

Figure I-7.--Larvae of the lodgepole pine terminal weevil feed in the phloem and pith (below); the result may be a crooked, forked, or multiple-stemmed tree (right).



Nymphs feeding on grass leaf

Native insect damages introduced grass species

A native insect, Labops herperius Uhler, has seriously damaged seeded ranges of crested wheatgrass varying from a few to several hundred acres in New Mexico, Colorado, and Wyoming. This unimportant native, which has become an important pest of an exotic plant, has been tentatively named the crested wheatgrass bug. By sucking plant juices, this insect causes stunted growth and reduced forage production and seed yield. Infested leaves turn yellow or white. Heavy damage for several years may kill the crested wheatgrass.

Figure 1-8.--This pest, harmless to native grass species but injurious to crested wheatgrass, has tentatively been called the crested wheatgrass bug. Adults are about one-fourth inch long.

Healthy clump

Injured clump

Forest Disease Research

Toxonomy of pine dwarfmistletoes in southern Arizono clorified

Recent field and herbarium studies have shown that there are two dwarfmistletoes on hard pines in southern Arizona, one of which is a previously undescribed species.

Arceuthobium vaginatum (Willd.) Presl forma cryptopodum (Engelm.) Gill is parasitic on Pinus ponderosa var. scopulorum, P. ponderosa var. arizonica, and P. engelmannii. This is the common ponderosa pine dwarfmistletoe of the Southwest, which ranges from Utah and Colorado south into Mexico.

Arceuthobium gillii Hawksworth and Wiens attacks only Pinus leiophylla var. chihuahuana. This new species has been named in honor of Dr. Lake S. Gill, former Chief of the Division of Forest Disease Research at this Station. It has been collected in the Santa Catalina, Rincon, Huachuca, and Chiricahua mountain ranges in southern Arizona. It also occurs in Sonora and Chihuahua, Mexico, but has not yet been collected in New Mexico.

In addition to host differences, these two dwarfmistletoes also differ in several physiological and morphological characteristics as shown below:

	Arceuthobium vaginatum	Arceuthobium gillii
Flowering period	May-June	February-March
Seed dispersal period	July-August	October-November
Typical shoot color	Orange	Greenish
Fruits	Non-glaucous	Glaucous

Pine dwarfmistletoe ot Grond Conyon ossocioted with conyon rim

The dwarfmistletoe-infected ponderosa pine stands on the plateau adjacent to the south rim of Grand Canyon, Arizona, show a definite association with the canyon rim (fig. D-1). Ponderosa pine covers about 200 to 300 square miles in this area, but the parasite occurs on only about 30 square miles near the rim. Most infected stands are confined to a narrow belt about 2 miles wide, paralleling the rim. Near Grandview Point, however,

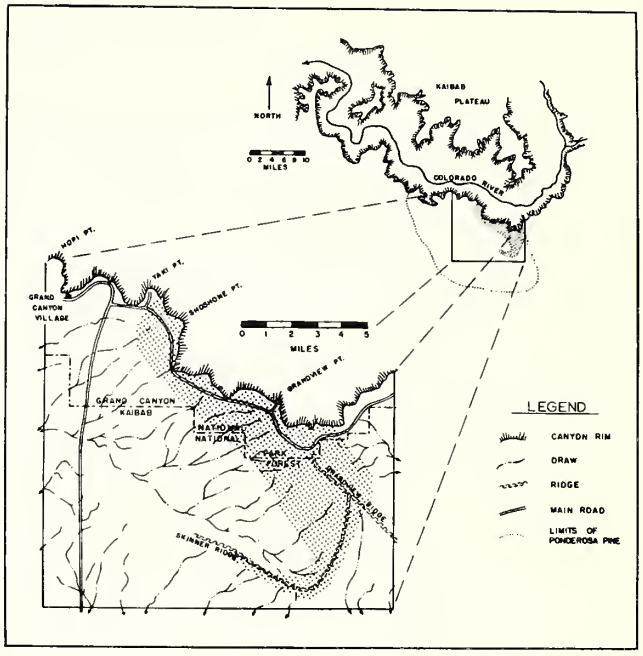
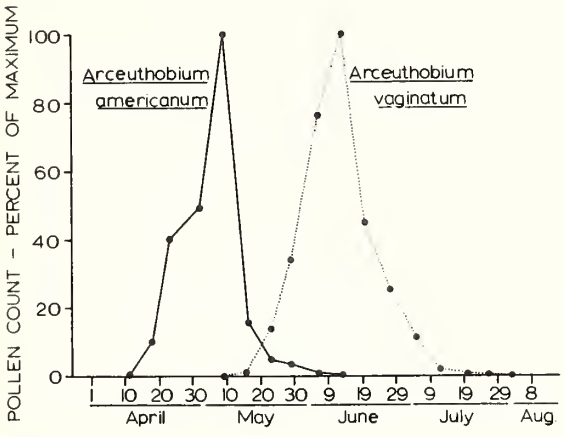


Figure D-1.--Distribution of dwarfmistletoe and approximate limits of ponderosa pine at the Grand Canyon.

diseased stands extend south of the rim for about 6 miles along a broad ridge. The reason for this peculiar dwarfmistletoe distribution is unknown, but it seems to be a result of climatic factors associated with the canyon rim.

Dwarfmistletoe flowering periods measured

Flowering periods of two dwarfmistletoes (Arceuthobium americanum on lodgepole pine and A. vaginatum forma cryptopodum on ponderosa pine) were measured in 1962 in one locality on the Roosevelt National Forest, Colorado. The duration of the flowering period was determined by weekly counts of pollen grains caught on vaseline-covered slides exposed near male plants (fig. D-2). For A. americanum, pollen dispersal occurred from April 11 to June 13, with about 90 percent of the pollen caught during a 3-week period from April 18 to May 9. In A. vaginatum, pollen was dispersed from May 9 to August 8, but about 90 percent of the pollen was caught during a 5-week period from May 23 to June 28.



Dwarfmistletoe seed discharge photographed

In preliminary attempts to photograph dwarfmistletoe seed discharge, a speed of 1/5,000 of a second was found to be too slow to stop the action, so a speed of 1/200,000 of a second was used (fig. D-3). The photographs revealed several previously unknown aspects of the seed discharge process. The seeds start to tumble in the vertical plane soon after they leave the fruit. Most seeds turned by a quarter circle after they had traveled only 2 inches. It had been previously supposed that the seeds remained aligned along their flight axis for some distance because their shape approaches that of an ideal projectile.

Also, the seeds are squarish at their trailing ends as they leave the fruit due to an attached viscous sheath. This sheath disintegrates after the seeds have traveled about 1 inch, so it does not act as a rudder as some scientists had supposed.

Figure D-2.--Periods of pollen dispersal for A. americanum and A. vaginatum during 1962.

Figure D-3.--Seed expulsion in Arceuthobium. A. Taken at a speed of 1/5,000 of a second. Seed out of view to left. B. to G. Taken at 1/200,000 of a second. B. Seed with viscous sheath intact. C. Oblique end view of seed shows sheath and indentation. D. and E. Stages in the disintegration of the viscous sheath. F. and G. Seeds in flight 3 to 4 cm. from fruit.

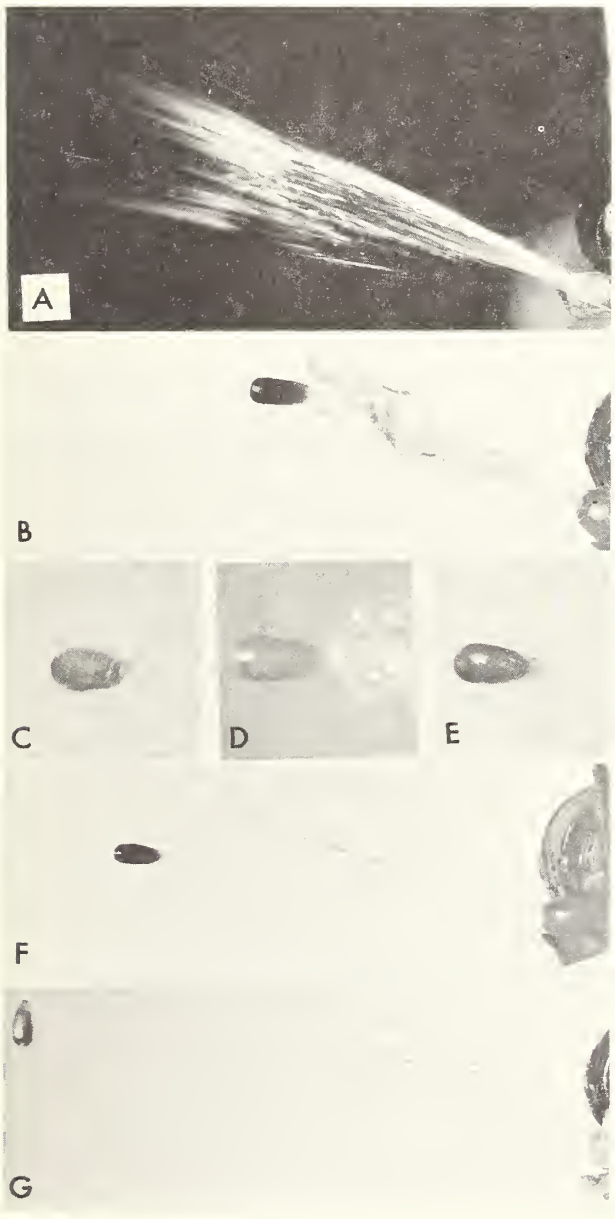


Figure D-4.--Pathologist adds nematode suspension to a battery of Baermann funnels used in recovering nematodes from forest and woodland soils in New Mexico.

Plant parasitic nemotodes recovered from New Mexico forest soils

Samplings of ponderosa pine (Pinus ponderosa Lawson), pinyon (P. edulis Engelm.), and juniper stands yielded 11 genera of plant parasitic nematodes, 2 genera of suspected plant parasites, and at least 3 genera of predatory nematodes (fig. D-4). The 11 genera of plant parasitic nematodes have all been reported to be associated with the rootlets of tree species, although parasitism has not been proven for a few. Of the plant parasitic genera, 11 were associated with ponderosa pine, 9 with pinyon, 8 with alligator juniper (Juniperus deppeana Steud.), 6 with Rocky Mountain juniper (J. scopulorum Sarg.), and 4 with one-seeded juniper (J. monosperma (Engelm.) Sarg.). The ultimate objective of this work is to determine the role of nematodes in the decline and mortality of marginal ponderosa pine and its woodland associates after prolonged drought in Arizona and New Mexico.

Nematode damage to nursery conifers controlled with chemicals

Root lesion nematodes (Pratylenchus penetrans) damaged nursery stock of eastern redcedar (Juniperus virginiana L.), Rocky Mountain juniper, white spruce (Picea glauca (Moench) Voss), and Colorado blue spruce (P. pungens Engelm.) in the Bessey Nursery, Halsey, Nebraska (fig. D-5). Infestations were associated with nursery windbreaks of eastern redcedar. Both Dowfume MC-2 and Vapam gave good control as judged by plant response, with the former better for spring planting and the latter suitable for late summer or fall.

Figure D-5.--Eastern redcedar seedlings (2 - 0). Top height of healthy seedling is 21 cm.; height of seedling infested with root-lesion nematode is only 10 cm.

Fungicides control Cylindrosporium leafspot

Several fungicides were tested against natural outbreaks of Cylindrosporium leafspot on silver buffaloberry (Sheperdia argentea (Pursh) Nutt.) and skunkbush sumac (Rhus trilobata Nutt.) in 1962. This leafspot defoliates and stunts nursery seedlings in the central Great Plains. Either Captan or Maneb gave good control on both species when applied at weekly intervals from June 15 to August 31. Bordeaux mixture was nearly as effective, but retarded growth slightly on sumac.

The extent of defoliation on treated and untreated plots was as follows:

	Buffaloberry (Percent)	Skunkbush sumac (Percent)
Maneb	28	16
Captan	24	18
Bordeaux mixture	30	22
Check	68	90

Timber Management and Forest Fire Research

Clear cutting recommended for harvesting old-growth lodgepole pine

The effect of four cutting treatments on subsequent growth and mortality was tested in old-growth lodgepole pine (Pinus contorta Dougl.) on the Fraser Experimental Forest, Colorado, from 1940 to 1960. Because of heavy mortality and low net growth in the partially cut stands, clear cutting is recommended. The treatments included:

1. Commercial clear cut. All trees 9.6 inches d.b.h. and larger were harvested. The residual stand of smaller trees was retained.

2. 2,000 board foot reserve. A growing stock of 2,000 bd. ft. per acre of the thriftiest trees 9.6 inches d.b.h. and larger was left. The method resembled scattered seed-tree cutting except that no special attention was paid to a tree's capacity to produce seed.

3. 4,000 board foot reserve. A growing stock of 4,000 bd. ft. per acre of the better trees 9.6 inches d.b.h. and larger was left. The method simulated a modified shelterwood or heavy selection cutting.

4. 6,000 board foot reserve. This treatment removed about half the original volume in trees larger than 9.5 inches d.b.h. The method simulated the initial step of a shelterwood cutting.

5. Uncut.

Gross growth during the first 7 years, including ingrowth, was substantial only where half or more of the original volume was left: in the uncut stand and 6M bd. ft. reserve. Larger gross increments were attained with all treatments after 1947, but only the 6M bd. ft. reserve outgrew the uncut stand (table T-1).

Average annual mortality in the partially cut stands exceeded that in the uncut stand from 1940 to 1947. Heavy windfall losses nearly equaled gross increment in the 6 M bd. ft. reserve and exceeded gross increment in the 2 M bd. ft. and 4 M bd. ft. reserves. No measurable mortality occurred after commercial clear cutting because there were no trees of merchantable size left. After 1947, mortality was much less on the uncut and partially cut plots, and new increment increased (table T-1).

Table T-1.--Periodic annual increment and mortality, old-growth lodgepole pine in Colorado

	Commercial clear cut	2 M bd. ft. reserve	4 M bd. ft. reserve	6 M bd. ft. reserve	Uncut
			Board feet		
First 7 years, 1940-47:					
Gross increment	36	59	79	104	104
Ingrowth	36	40	34	41	26
Mortality	0	103	125	88	74
Net increment	36	-44	-46	16	30
Last 13 years, 1948-60:					
Gross increment	52	92	99	135	130
Ingrowth	41	57	42	46	34
Mortality	1	6	28	20	45
Net increment	51	86	71	115	85
Twenty-year period, 1940-60:					
Gross increment	47	80	92	124	121
Ingrowth	39	51	39	44	31
Mortality	1	40	62	44	55
Net increment	46	40	30	80	66

Without ingrowth, there would have been no net increment in the 6 M bd. ft. reserves and little in the uncut stands during the first 7 years after cutting. After 1947, ingrowth was still responsible for nearly two-thirds of the net increment in the 2,000 bd. ft. reserves and about 40 percent of the net increment elsewhere. Nearly all net increment on commercial clear-cut areas was ingrowth during the 20-year period of observation.

Lodgepole pine reproduces well after clear and heavy-partial cutting

Advance reproduction on the areas described in the foregoing item was sparse before logging, about 1,800 seedlings and saplings per acre (table T-2).

Logging with horses, plus slash disposal, destroyed about 44 percent of the advance growth on the treated plots and reduced milacre stocking. Stocking on individual plots ranged from 32 to 42 percent (table T-2). Loss of reproduction was not related to volume of timber removed.

Regeneration came in rapidly after logging and increased nearly threefold on all cutover areas in 7 years. The increase was inversely related to the volume of reserve stand: greatest on the clear-cut area and least under the 6 M bd. ft. reserve. As new reproduction became established during the first 7 years after logging, the number of stocked milacres increased nearly twofold on all cutover areas. Increase in stocking was proportional to the amount of original overstory removed (table T-2).

New reproduction continued to become established after 1947, but at a much lower rate. The largest increases after 1947 were under reserve stands of 4,000 bd. ft. or less, where established new reproduction was more than twice that under the 6 M bd. ft. reserve. The level of stocking remained nearly constant after 1947 (table T-2).

Single-tree thinning recommended over crop-tree thinning

Single-tree thinning of 35-year-old lodgepole pine on the Fraser Experimental Forest

Table T-2.--Number of seedlings and saplings per acre and percentage of milacres stocked after commercial clear cutting and partial harvest of old-growth lodgepole pine

Stocking condition in various years	Commercial clear cut		2 M bd. ft. reserve		4 M bd. ft. reserve		6 M bd. ft. reserve		Uncut	
	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.
Before logging, 1940	2,013	--	1,970	--	2,497	--	1,430	--	1,137	--
After logging, 1940	1,281	40	1,079	39	1,249	42	848	32	1,137	--
New trees started, 1940-47	2,665	--	2,236	--	2,415	--	1,481	--	305	--
Total all trees, 1947	3,729	80	3,232	76	3,518	76	2,181	61	1,319	53
New trees started, 1948-60	714	--	862	--	984	--	359	--	70	--
Total all trees, 1960	4,124	79	3,734	74	4,180	74	2,314	56	1,130	46

in 1945 stimulated growth more than crop-tree thinning. Single-tree thinning reserved an average of 630 of the better trees per acre, spaced 8.5 feet apart. Crop-tree thinning released approximately 100 trees per acre, spaced 21 feet apart, by cutting openings 16 feet in diameter around each "crop" tree. The remaining trees outside the cleared circles were left standing.

Growth in diameter of the best 100 trees per acre was 1-3/4 times greater on single-tree plots, and 1-1/2 times greater on crop-tree plots, than on the best 100 trees on unthinned plots during the first 8 years after thinning. For the second 8 years (1953-61) diameter growth of the best 100 trees per acre was the same on the two thinned plots; about 1-1/2 times faster than on the unthinned. Average diameter growths of the best 100 trees by three treatments were:

	Unthinned	Crop-tree thinning	Single-tree thinning
	- - - -	(Inches)	- - - -
After thinning,			
1945	4.33	3.90	4.29
1953	4.96	4.84	5.42
1961	5.48	5.71	6.32
Annual increase:			
1945-53	.08	.12	.14
1953-61	.07	.11	.11

Average annual diameter growth of all trees on the single-tree plots was four times greater during the first 8 years of the thinning and two times greater during the second 8 years than in unthinned stands. Average diameter growth of all trees was only slightly greater on the crop-tree plots than on the unthinned plots for the whole 16 years of record, as shown below:

	Unthinned	Crop-tree thinning	Single-tree thinning
	- - - -	(Inches)	- - - -
Before thinning,			
1945	1.93	1.95	2.03
After thinning,			
1945	2.00	2.24	3.20
1953	2.25	2.54	4.20
1961	2.56	2.96	4.83
Annual increase:			
1945-53	.03	.04	.12
1953-61	.04	.05	.08

Cubic-foot volume growth, as shown in the following tabulation, was greater on the unthinned than on the thinned plots for the first 8 years after thinning. But by 1953, both thinning treatments had regained sufficient volume to maintain a rate of growth comparable with unthinned stands. Equal volume growth after 1953 indicated that both thinning treatments were utilizing the site as fully as the unthinned plots.

	Unthinned	Crop-tree thinning	Single-tree thinning
	- - -	(Cubic feet)	- - -
Before thinning	1,036	998	1,087
After thinning	1,174	612	438
1953	1,728	992	840
1961	2,204	1,488	1,330
Annual increase:			
1945-53	69	48	50
1953-61	60	62	61

The increased diameter growth of all trees on the single-tree thinned plots was accompanied by a substantial increase in pulpwood volume (trees 5.0 inches d.b.h. and larger). The tabulation below shows that, in the 16 years after thinning, the single-tree plots produced 354 cubic feet more of pulpwood-size material than the unthinned stands, whereas the crop-tree plots produced only 29 cubic feet more:

	Unthinned	Crop-tree thinning	Single-tree thinning
	- - -	(Cubic feet)	- - -
After thinning	220	104	105
1953	467	335	480
1961	827	740	1,066
Annual increase:			
1945-53	31	29	47
1953-61	45	51	73

Southwestern ponderosa pines grow best when planted to standard depth

Ponderosa pine (Pinus ponderosa Laws.) transplants grew much better when planted to the same depth as they grew in the nursery than when planted with only the terminal buds exposed. The trees averaged approximately the same size and weight when planted in April. By October the trees planted to standard depth were more than twice as large and weighed more than twice as much as the deep-planted trees (table T-3).

New roots of deeply planted transplants first appeared at an average depth of 10.8 inches compared to 8.4 inches with standard planting. Roots of the trees planted at standard depth, however, penetrated 2 feet into the soil 33 days earlier than roots of trees planted to the terminal bud. Transplants with robust tops, and roots that penetrate quickly into deep, moist soil layers are better able to resist drought and enemies.

Planted ponderosa pines survive best on herbicide-treated plots

Herbicides are efficient tools for killing grasses on areas to be planted to trees, and the mat of dead grass has been found to be an excellent moisture-conserving mulch. To test for residual toxicity in the soil from use of herbicides, ponderosa pine seedlings (2-0) were planted in April 1962 on plots in Arizona treated in 1961 with various herbicides (fig. T-1).

As shown below, first-year survival was generally better on plots sprayed with dalapon, diethylene glycol bisester of dalapon, simazine, and amitrol T than on scalped plots; poorest survival was on untreated check plots. Residual toxicity, if any, had no discernible effect on the seedlings.

Table T-3.--Growth of deeply planted and normally planted 2-1 ponderosa pine transplants during one growing season

Method of planting	Root volume	Top volume	Green weight	Dry weight
	Cubic centimeters		Grams	
Deep planting:				
When planted (April)	3.3	6.2	10.8	--
End of study (October)	9.0	9.0	17.2	4.6
Standard planting:				
When planted (April)	3.4	6.6	10.8	--
End of study (October)	21.2	21.9	41.1	11.6

	Rate of application (Lbs./acre)	Estimated grass kill (Percent)	Tree survival (Percent)
Plots treated with:			
Dalapon (sodium salt)	5	80	75
	10	85	55
	15	90	70
Diethylene glycol bisester of dalapon	5	70	65
	10	90	65
	15	100	75
Simazine	10	80	75
	20	90	85
	40	90	60
Amitrol	10	40	50
	20	60	30
	40	75	40
Amitrol T	10	70	40
	20	95	70
	40	100	65
Ammonium thiocyanate	10	10	55
	20	10	45
	40	35	55
Scalped plots	0	100	60
Untreated plots (check)	0	0	20

Windbreak conifers respond to release from overtopping

Twenty-year-old eastern redcedars (Juniperus virginiana L.) and ponderosa pines in crowded Nebraska windbreaks were released on one or two sides by cutting adjacent rows of green ash (Fraxinus pennsylvanica Marsh.) and Russian-olive (Elaeagnus angustifolia L.). Three years after treatment, the vigor of all released trees had improved as shown by increased growth and changes in foliage. Diameter growth increased as shown below:

	Before treatment (inches)	3-year increase (inches)
Eastern redcedar:		
Released 2 sides	3.87	0.81
Released 1 side	3.61	.69
No release	3.90	.35
Ponderosa pine:		
Released 2 sides	3.96	.63
Released 1 side	3.43	.45
No release	3.60	.22

Trees released on two sides increased in height almost twice as much as unreleased trees. Trees released on one side increased in height slightly faster than unreleased trees. They are still suffering loss of terminal growth from rubbing and whipping by the remaining row of hardwood trees.

Figure T-1.--Spots of dead grass are beginning to appear in this dense stand of Arizona fescue (Festuca arizonica Vasey) and mountain muhly (Muhlenbergia montana (Nutt.) Hitchc.) after treatment with herbicides.

Figure T-2.--Redcedars were pale in color and low in foliage density before release in 1959 from overtopping by Russian-olive and green ash.

Figure T-3.--Three years after treatment, foliage of the redcedars has increased in density and turned dark green.

Increased density and vigor of foliage of the released trees improved the efficiency of the windbreaks (figs. T-2, T-3).

Crowded windbreak hardwoods improved by remaving adjacent raws

Closely spaced rows of green ash, hackberry (Celtis occidentalis L.), honeylocust (Gleditsia triacanthos L.), Siberian elm (Ulmus pumila L.), and American elm (Ulmus americana L.) in Nebraska were released on one and two sides by cutting adjacent rows of deciduous trees.

Two years after treatment, diameters had increased in direct proportion to the amount of release; foliage had thickened greatly and the crowns were spreading out to fill in the openings created by cutting (figs. T-4, T-5). Prolific clumps sprouted from the stumps of cut trees (fig. T-6).

Honeylocust, hackberry, and Siberian elm produced epicormic branches throughout the length of their boles. Epicormic branches and sprouts will increase foliage density near the ground in grazed and degraded windbreaks.

Composition and density of the ground cover vegetation changed within the cleared rows. Large numbers of redcedar and Siberian elm seedlings appeared.

Figure T-4.--The row of hackberry (left) was released on two sides and the row of Siberian elm (right) was released on one side.

Figure T-5.--Foliage has thickened and crowns expanded in the 2 years since release. Many redcedar and Siberian elm seedlings have appeared.

Figure T-6.--Sprouts from stumps of hackberry trees. Two years after cutting, sprouts of Siberian elm averaged 7.5 ft.; green ash, 8.4 ft.; honeylocust, 5.6 ft.; and hackberry 4.9 ft.

Volume tables and point-sampling factors for southwestern ponderosa pines

U.S. Forest Service Research Paper RM-2 presents volume, taper, and volume distribution tables for blackjack and old-growth southwestern ponderosa pines. Volumes are given in total cubic feet, cubic feet to a 4-inch top d.i.b., board feet Scribner Rule, and board feet International 1/4-inch Rule for total heights and heights in logs. Research Paper RM-3 presents cubic-foot and board-foot volumes per square foot of tree basal area, for use in volume determinations by point-sampling.

Intentional burns produce similar results under similar conditions

Two intentional burns in ponderosa pine in Arizona gave similar results, although done by different people in different years and on areas of greatly different size. An area of 27,000 acres was burned when the drought index was high (77) and the rate-of-spread index was low to moderate (5-20). An area of 100 acres was burned when drought index was moderate (70) and rate-of-spread index was low (10). In both cases, burning conditions produced low-intensity or "cool" fires.

Light surface fire covered 78 percent of the burned area on the smaller fire and 73 percent on the larger. Hot surface fires covered 18 and 21 percent of the burned areas, respectively. Seventeen percent of the larger area and 38 percent of the smaller area failed to burn.

Ten percent of the potential crop trees in need of release on the smaller area, and 21 percent on the larger area were released. Although 23 percent of the fuels on the smaller area had a potential for supporting crown fire, only 4 percent of the burned area was damaged by crown fire. On the larger area, the potential was 11 percent and the actual crowned area was 6 percent. These differences may be attributed to lower drought index and greater effort to control fire behavior on the smaller burn.

Chemicol desiccation of chaparral reduces moisture and flammable substonces

Chemical desiccation of chaparral with oil-water emulsions of 2,4-D and 2,4,5-T reduced water content about 90 percent and ether-extractable chemicals by three-eighths to three-fourths (fig. T-7). These changes increased flammability slightly in two species and reduced it in another.

Gain in heat output during combustion because of reduced moisture content was largely offset by a decrease in flammable waxes, fats, and oils in shrub live oak (Quercus turbinella Greene) and Wright silktassel (Garrya wrightii Torr.). Loss in potential heat yield of pointleaf manzanita (Arctostaphylos pungens H.B. K.) appeared to be appreciably larger than the gain. Chemically desiccated manzanita has not been so flammable as untreated manzanita in burning tests.

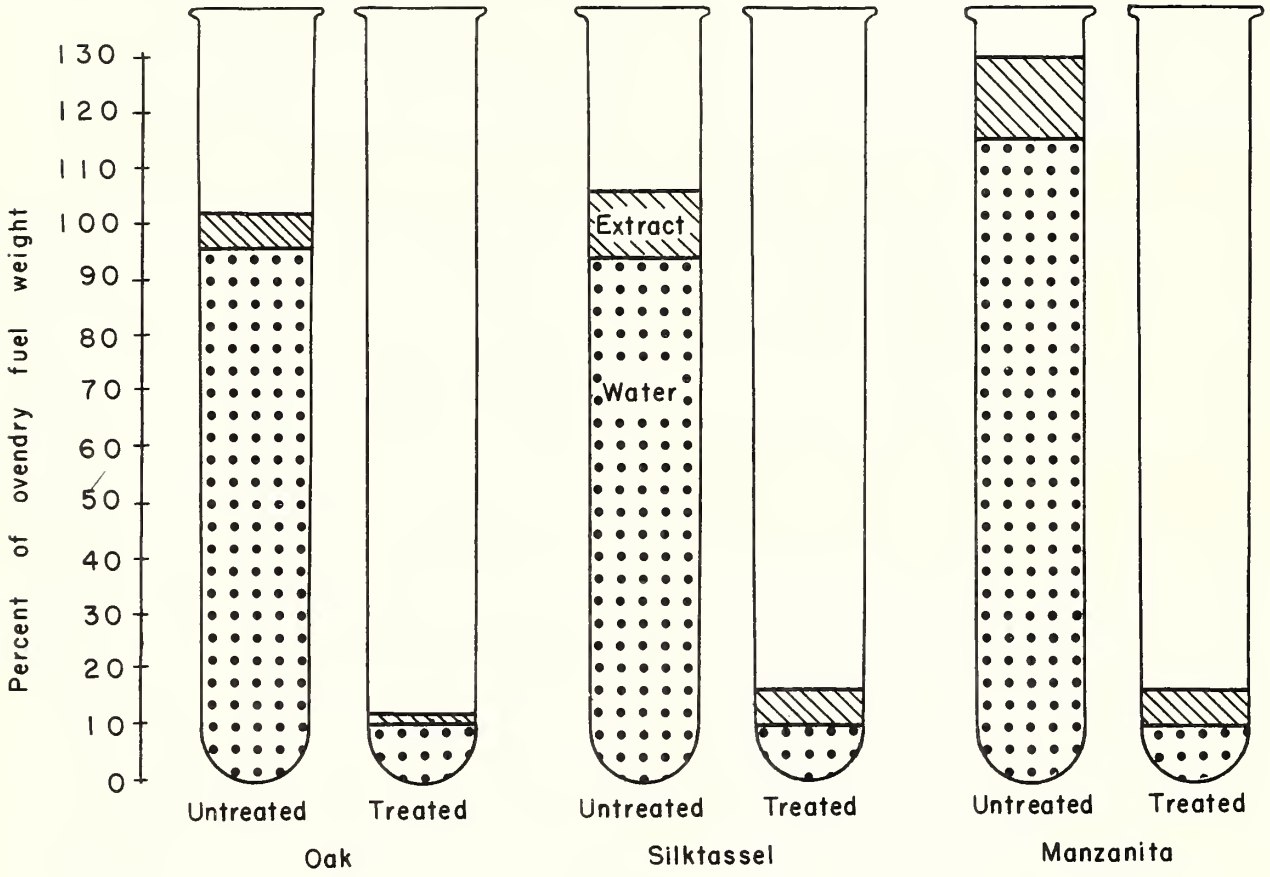
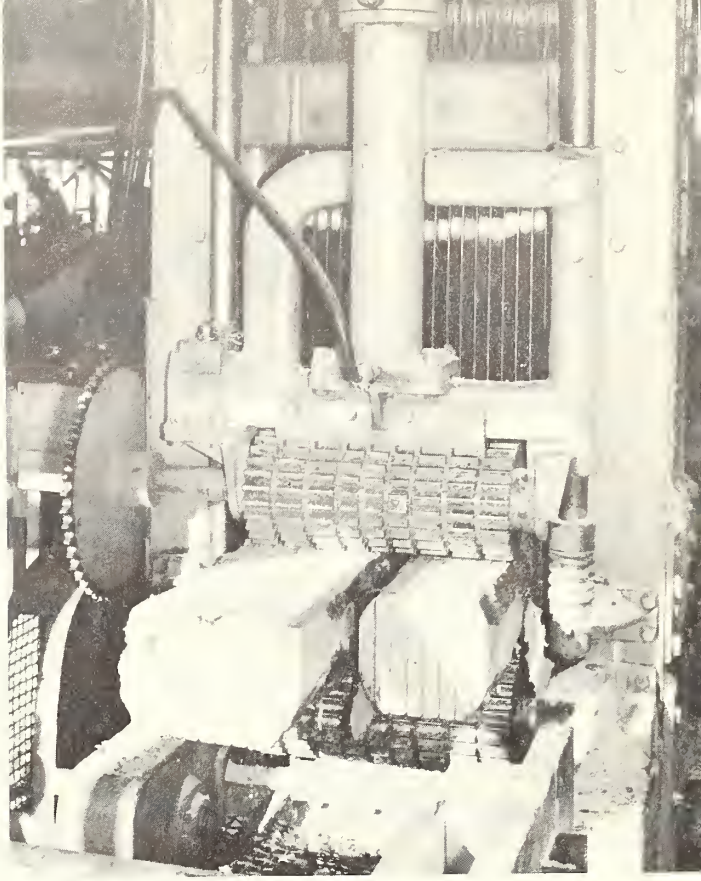


Figure T-7.--Reduction of moisture and ether extract content caused by chemical desiccation.

Forest Utilization Research



Lumber recovery study in Black Hills praves adequacy af tree volume tables

Results of a lumber recovery study conducted on Black Hills ponderosa pine showed that the net tree volume tables currently being used to determine the timber volumes on proposed sale areas are adequate for the purpose. Results were based on a sample of 500 trees selected to sample the range of sawtimber sites and diameters common to the area. Selection was made by a crew representing the lumber producers, the Black Hills National Forest, and the Rocky Mountain Station. Tree volume data are compared with log scale and net lumber recovery in the following tabulation:

Volume table:		
Standing	186,910	142,620
Felled	194,660	148,650
Log scale, Scribner Decimal C	190,030	147,180
Lumber tally, dry finished	--	146,440

Impraved panderasa pine log grades wark well in Black Hills

Improved ponderosa pine log grades[1] were tested for application to Black Hills ponderosa pine sawtimber. They were found to be easier to apply than the log grades developed earlier by Pacific Northwest Forest and Range Experiment Station (PNW), and in general provided a better distribution of the logs by quality classes. The study was based on 1,468 logs selected to sample the range of diameters and grades of saw logs found in the Black Hills forests.

Table U-1 compares the two grading systems by log distribution, and percent lumber recovery by grade and per M value.

[1] *Gaines, E. M. Improved system for grading ponderosa pine and sugar pine saw logs in trees. U. S. Forest Serv. Pacific Southwest Forest and Range Expt. Sta. Tech. Paper 75, 21 pp., illus. 1962.*

Table U-1.--Lumber grade recovery from Black Hills ponderosa pine, measured by the PNW and improved ponderosa pine log grades

Log grade	Number of logs	Select			Mould-ing	Fac-tory select	No. 1 shop	Common				Value per M
		B	C	D				1 & 2	3	4	5	
		Percent										Dollars
PNW GRADES												
1	40	3.2	18.8	25.8	0.6	1.0	1.7	9.1	15.4	23.0	1.4	108.34
2	50	1.8	13.6	21.2	1.5	2.1	5.5	9.6	22.3	19.6	2.8	99.42
3	259	.9	7.3	13.7	.3	2.8	8.5	17.6	23.5	22.9	2.5	87.10
4	2	0	0	0	0	0	0	35.5	64.5	0	0	76.26
5	1,106	.1	1.1	2.9	0	1.8	6.7	22.1	33.1	28.7	3.5	71.38
6	11	0	.8	.8	0	1.7	13.2	1.9	27.3	47.4	6.9	60.48
Total	1,468	.6	4.5	8.1	.2	2.0	7.0	19.2	28.9	26.4	3.1	79.21
IMPROVED GRADES												
1	41	3.2	19.1	26.3	.7	1.1	1.7	9.4	15.4	21.7	1.4	109.41
2	103	1.7	11.6	20.1	.8	2.1	6.9	12.6	22.4	19.6	2.2	96.67
3	279	.6	5.6	10.5	.2	3.3	9.2	18.3	24.5	24.8	3.0	82.49
4	2	0	0	0	0	0	0	35.5	64.5	0	0	76.26
5	1,043	.1	.9	2.5	0	1.5	6.3	22.2	33.8	29.2	3.5	70.75
Total	1,468	.6	4.5	8.1	.2	2.0	7.0	19.2	28.9	26.4	3.1	79.21

Feasibility of weight scaling Black Hills saw logs under study

Weight measurement of Black Hills ponderosa pine saw logs is being investigated in an effort to find a low-cost, fast, and accurate method of determining the volume of logs removed from a timber sale.

A total of 223 logs were weighed and measured to determine a ratio of weight per cubic foot (fig. U-1). A preliminary regression analysis of total log weight on cubic feet of wood inside bark included all variables, and indicated that a sound weight per cubic foot ratio does exist. The regression formulas for sound, defective, and all logs did not differ appreciably (fig. U-2).

Further analyses are planned to determine the significance of variations in moisture content, specific gravity, percent heartwood, percent bark, and percent defect.

Additional studies are planned to find whether there is a relationship between cubic foot volume and board foot volume, and to find any variation in green log weight with season and the amount and rate of log weight loss in storage.

Figure U-1.--Weighing Black Hills ponderosa pine saw logs with a tripod, chain hoist, and hydraulic load cell.

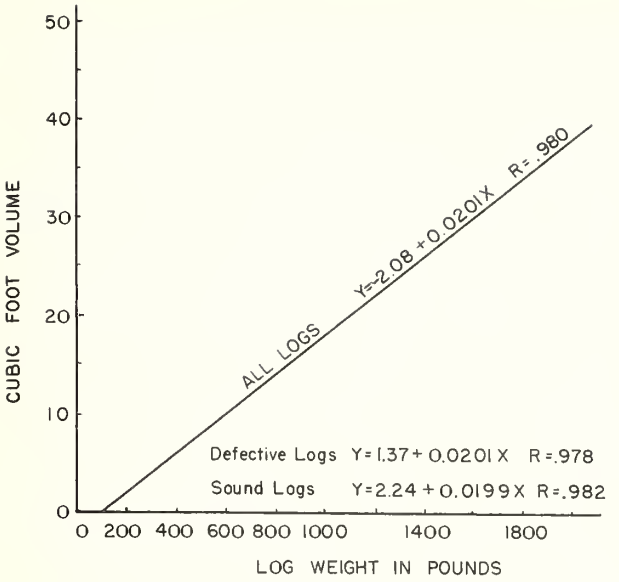


Figure U-2.--Relation of Black Hills ponderosa pine saw-log weight to cubic foot volume, inside bark.

Product development from low-quality ponderosa pine continues

Efforts to utilize more low-quality softwood sawtimber are keyed to creating products that can either circumvent or tolerate the range of defects common to low-grade timber, and that are more competitive with other building materials. A disadvantage of lumber as sheathing is the high labor cost in its installation. Panel products, combined-function products, and semifinished products all reduce installation costs. A current trend toward coordinated component building systems illustrate a further need to consider related groups of products rather than single products.

The development and evaluation of several promising products from low-quality material was reported in last year's Annual Report. Additional panelized or semifinished building products that offer promise for effective utilization of low-grade timber include:

Particle board decking or partitioning. -- A specialized 1-3/4-inch-thick particle board has shown up well experimentally for use as partitioning and roof decking. The board consists of standard coarse pulp chips as core material and conventional 0.015-inch flakes in in the face plies (fig. U-3). Coarse chips for such a board can be produced from extremely low-grade, rough material.

The particle board was manufactured in 2-foot by 8-foot panels, then trimmed and routed to accept a splined connecting moulding. The panels can be prefinished and splined together to form a unique and attractive finished partition. No framing or additional finish work is required. A completed office partition is shown in Figure U-3.

Panels were subjected to internal bond and static bending strength tests, accelerated aging tests, and dimensional movement tests. The results, all highly satisfactory, indicate superior qualifications for the uses suggested, including use as an insulating roof decking.

Lumber-core laminated flooring. -- Floors designed for a resilient floor covering conventionally require both a subfloor and an underlayment floor. Lumber-core laminated flooring was conceived as a dual-purpose product combining the functions of subfloor and underlayment. It could also be used as a combination roof and ceiling decking. This laminated material can be designed to apply over a range of floor or roof beam spacings as well as over conventional floor framing. The product can significantly reduce installation costs of these basic building components, and also serve to better display the natural beauty of wood.

Test panels of the flooring were made with 25/32-inch lumber for the core, laminated to 1/4-inch rotary-cut veneer face and back plies with a phenol-resorcinol adhesive in a cold press.

Both core material and veneer may contain extensive sound defect. Cores were made from standard lumber of the lowest common grades (fig. U-4). Finished panels were edge-matched with tongue-and-groove to eliminate the need for blocking between joists.

Test sections from the flooring panels were subjected to stiffness and strength tests (fig. U-4), and tests of dimensional stability and glueline integrity. Strength test results

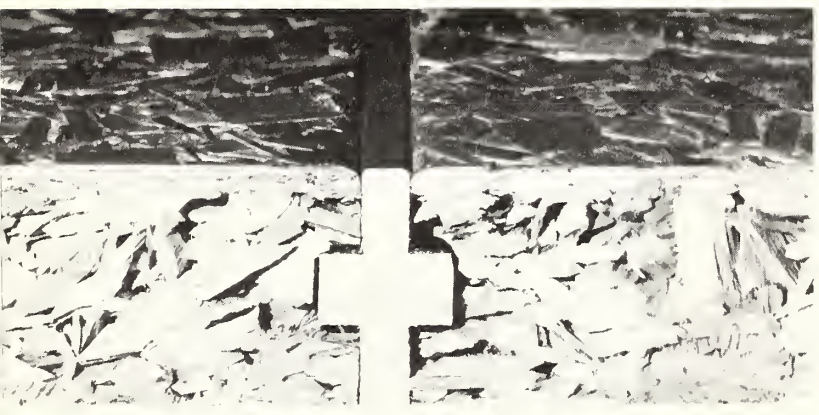
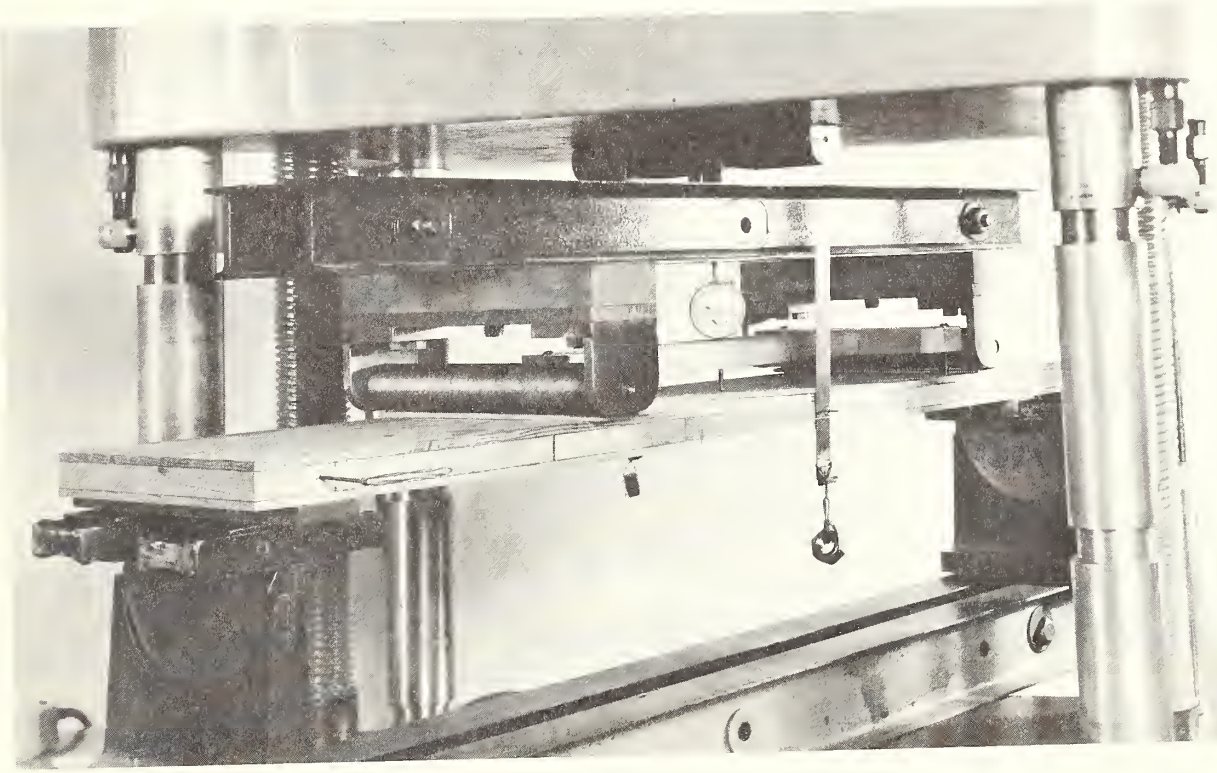


Figure 4-3.--Office partition of thick particle board is attractive, a sound barrier and eliminates need for wall framing.

Left, arrangement of chips and particles in the board, and sample spline used to join panels.



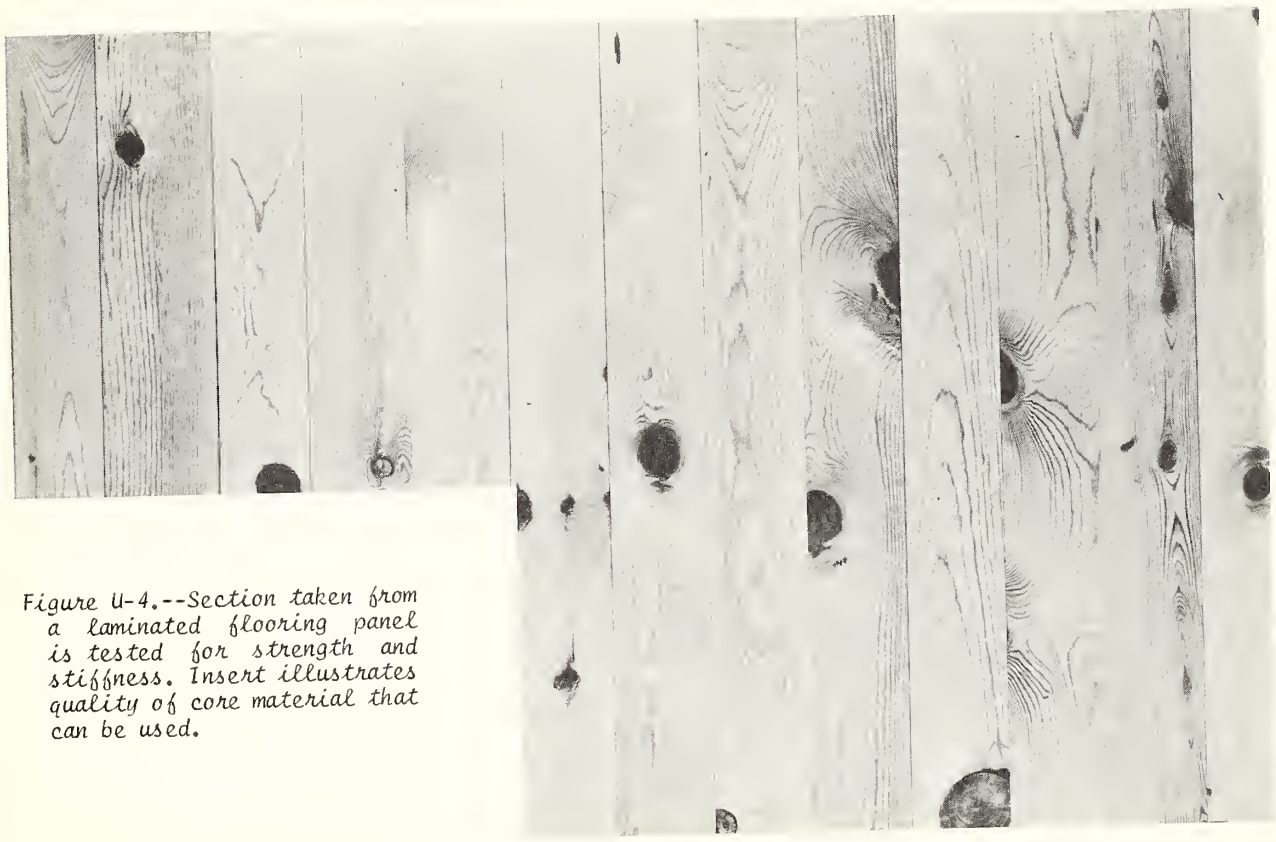


Figure U-4.--Section taken from a laminated flooring panel is tested for strength and stiffness. Insert illustrates quality of core material that can be used.

indicated that certain limitations upon allowable defects in face veneers are necessary. Aside from this, product performance is quite satisfactory. The design concept of sandwiching a lumber core between heavy veneer faces appears to be entirely valid, and could have wide application in the utilization of low-grade lumber.

Specific grovity of lodgepole pine in Colorado and Wyoming

Specific gravity is recognized as the best single property for evaluating potential new uses of timber species. It is an especially good indicator of strength properties and pulp yields. Thus the specific gravity of 444 lodgepole pines distributed over Colorado and Wyoming was studied intensively to expand and improve market outlets for this Rocky Mountain species. The average whole-tree specific gravity was found to be 0.394.

Samples were taken at intervals along the length of the tree to study the relationship of specific gravity to position in the tree. Specific gravity decreased rather sharply in the first 10 feet of height, then declined more gradually up to 20 feet. It remained relatively constant between 20 and 50 feet in height, after which it tended to increase. The highest correlation between the average specific gravity for the whole tree and individual samples was found at breast height.

Forest Economics Research

FOREST RECREATION

Patterns of summer recreational use

Visitor use of 12 selected recreation sites in the National Forests of Arizona, New Mexico, Colorado, Wyoming, and South Dakota was systematically observed during the summer of 1962. Each site was observed twice for a period of 4 days, once between mid-June and the end of July, and again between early August and mid-September. The purpose was to establish use patterns to guide future development and management of similar forest recreation areas.

Highlights of the findings are:

1. About 10 percent of the vehicles were pickup campers. The use of tents for camping exceeded travel trailers by a ratio of 1.5 to 1. The average number of visitors per party (4.8) is greater than the average number of visitors per vehicle (3.9).

2. The young adult (21-39 years) and children (13 years or less) were the dominant visitors. Next in importance was the middle-aged adult (40-59 years), followed by the teenagers (14-20 years).

3. The bulk of visitor-hour use is attributed to camping. In general, day users account for less than 10 percent of the total visitor hours. People who camped stayed on the average 27.35 hours per visitor; day users stayed on the average 2.35 hours per visitor.

4. Family units did not receive uniform use. Sixty percent of the units were used less than 6 hours per camping visitor.

Figure E-1.--Family units closer together than 100 feet are not used so much as those farther apart.

5. Total hours of daily use per visitor at each family unit appeared to be associated with the distance improvements are from the units.

   a. Units within 50 feet of the parking were used more than those over 50 feet.
   b. Units between 51 and 200 feet from toilets were used more than those within 50 feet or over 200 feet.
   c. Units within 150 feet of drinking water were used more than those over 150 feet.
   d. Units over 100 feet apart were used more than those closer together (fig. E-1).
   e. Units between 51 and 200 feet from a fishing point (lake or stream) were used more than those within 50 feet or over 200 feet.
   f. Units with a "clearing" of over 10 feet in radius from the fire grate were used more than those with less (fig. E-2).

Figure E-2.--Family units with a "clearing" over 10 feet in radius from the firegrate are used more than units with less.

6. In the first period, 17 percent of the 514 family units were never used by incoming new parties, and 29 percent were never used in the second period (fig. E-3). Only about 10 percent of the family units were selected by five or more incoming new parties during the 4-day observation periods (fig. E-4).

Figure E-3.--This family unit was never used by incoming new parties during either observation period.

Figure E-4.--Five or more incoming new parties selected this family unit during both 4-day observation periods. Average hours of daily use per visitor was 7.0 the first period and 5.6 the second. The unit was between 100 and 150 feet from the lake.

Land-management programs evaluated at Beaver Creek

The Beaver Creek Project is designed to evaluate costs and benefits of intensive multiple-use forest land-management programs in the Southwest. Its principal objective is to evaluate how management practices intended to increase runoff will affect water supply, sediment, timber and forage production, wildlife population, and recreation use of forest watershed lands.

The Beaver Creek watershed includes 275,000 acres in the ponderosa pine and pinyon-juniper cover types of northern Arizona. It lies on the southern edge of the Coconino Plateau, along the Mogollon Rim. Drainage is to the southwest into the Verde River. The area is subdivided into 18 small watersheds (100 to 2,000 acres) and 6 large watersheds (up to 100,000 acres).

Individual watersheds will be treated first with a single-treatment prescription. In the pinyon-juniper type, converting the tree overstory to grass and forbs is the treatment contemplated (fig. E-5). Pine watersheds will be subjected to various thinning and clearing treatments. Four of the larger watersheds will be used to test combinations of treatments and management systems, the objective being to find out how well results can be predicted when treatments are incorporated into the management of larger areas. The remaining two large watersheds are being used to develop operational techniques and determine treatment costs for large-scale operations. Large areas of pinyon-juniper and ponderosa pine have already been thinned and converted.

In addition to water, treatment effects on other products are being determined. Timber quality and growth are measured before and after treatment on the small watersheds, or before and after management redirection on the larger watersheds. Records are maintained on forage production and utilization, and on ecological trends. These are translated into beef gains and into deer habitat potential in supplemental studies. Actual game use is also being recorded, and hunter use is checked to assess the effect of treatment and management on this major recreational use.

Figure E-5.--Cabling and bulldozing juniper in a type conversion on a Beaver Creek experimental watershed.

Characteristics of
Beaver Creek area

The terrain consists primarily of undulating uplands dissected by many small drainageways. Basalt covers most of the region.

Three main vegetation types are: Lower Pinyon-Juniper Woodland, Upper Pinyon-Juniper Woodland, and Pine Forest. Principal tree species in the Lower Woodland type include Utah juniper (Juniperus osteosperma (Torr.) Little) and singleleaf pinyon (Pinus monophylla Torr. & Frem.); crown density in the type averages about 30 percent. In the Upper Woodland type, principal tree species are alligator juniper (Juniperus deppeana Steud.) and ponderosa pine (Pinus ponderosa Laws.); crown density averages about 15 percent. In the Pine Forest type are ponderosa pine and Gambel oak (Quercus gambelii Nutt.). Watershed 12, which is typical of the Pine Forest type, has a timber volume of about 1,500 cubic feet per square acre, 19 percent of which is Gambel oak. Watershed 11, though in the Pine Forest type, has been clear cut and seeded, and now has a grass cover.

Annual precipitation in inches for low, average, and high years is as follows for the three vegetation types:

	Low	Average	High
		(Inches)	
Lower Woodland	13	18	24
Upper Woodland	14	22	30
Pine Forest	17	25	34

Precipitation is heaviest in late summer and early spring. The summer storms are convective, sometimes totaling as much as 3 inches, with maximum half-hour intensities of about 2 inches per hour. Major winter and spring storms are frontal and more general in area. They too can produce as much as 3 inches per storm, but intensities are lower. The winter and spring storms may come as snow, rain, or a mixture.

Annual streamflow in inches for low, average, and high years is as follows for watersheds in the three vegetation types:

	Low	Average	High
		(Inches)	
Lower Woodland	0.0	0.4	0.8
Upper Woodland	.3	3.1	5.4
Pine Forest	.4	4.3	11.4

All streams on the watersheds are ephemeral, with most of the flow coming during winter and spring. About 99 percent of the flow from Pine Forest watersheds comes during winter and spring months, compared with 98 percent for Upper Woodland watersheds and 76 percent for Lower Woodland watersheds.

Herbage yield predicted from
soil texture and slope position

Since conversion of wooded areas to herbaceous vegetation is contemplated, knowledge of the potential herbage yield of individual sites is essential. A method of predicting herbage yield was developed based on the textural characteristics of the surface soil and position on the slope (fig. E-6). The prediction equation based on field textural data is $y = -652.3 + 1200.6\ x_1 \quad 250.8\ x_2$, where x_1 equals percent sand plus percent silt in the A horizon and x_2 equals slope position by 25-percent segments of the slope length. Soil survey maps were found to be quite valuable for extending textural data over large areas.

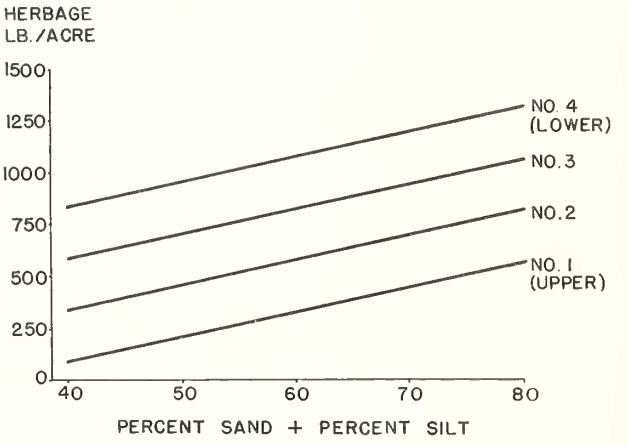


Figure E-6.--Herbage production as a function of soil texture and slope position.

An overstory inventory for multiple-use evaluation

An effort is being made on Beaver Creek to describe precisely the overstory on the various watersheds so that results may be extended to other areas (table E-1). Also, the overstory data should help to match treatments to watersheds, or to determine if it is rational to apply a particular treatment on a watershed.

An adequate description of the overstory characteristics should answer the pertinent questions raised in multiple-use management, such as:

"How much of the watershed needs to be treated to bring it to a particular specified stocking level?"

"Are the areas near stream channels more heavily stocked with trees than other areas?"

"What portion of the watershed is already covered with less than 40 square feet of timber, basal area, per acre?"

"What is the number and distribution of Gambel oak over 6 inches d.b.h. on the watershed for mast production?"

"How are large ponderosa pines distributed over the watershed?"

"What portion of the watershed is stocked with pine regeneration?"

"Will the existing distribution of different size classes of pine lend the watershed to a form of even-aged management, or should it be managed as an uneven-aged forest?"

A strip cruise is made so that stand tables can be constructed and growth determined by a stand-projection method. Point sampling is carried out along the strips to give proportions of areas stocked or not stocked by trees of different characteristics. Overstocking data under different criteria are also determined.

Site information such as aspect, slope percent, and slope position, is recorded at each point. A crown canopy photograph is taken at every other point for later use in forage measurements.

Table E-1.--A sample of timber inventory information from Beaver Creek watershed No. 12

Size class[1]	Number trees per acre	Basal area per acre	Volume per acre			Growth rate[2] per acre		
			Cubic feet	Board feet	Cords	Cubic feet	Board feet	Cords
PONDEROSA PINE								
Reproduction	245	--	--	--	--	--	--	--
Saplings	635	14.0	476.2	--	--	--	--	--
Small poles	131	16.3	233.4	--	1.0	16.8	--	0.03
Large poles	35.4	14.7	215.4	--	2.3	6.1	--	.07
Small sawtimber	9.78	9.4	180.7	604.3	1.8	5.2	17.8	.06
Medium sawtimber	5.64	12.2	314.1	1,455.2	--	.8	3.8	--
Large sawtimber	2.78	10.4	298.7	1,661.8	--	4.6	23.7	--
Total	1,064.60	77.0	1,718.5	3,721.3	5.1	33.5	45.3	.16
GAMBEL OAK								
Reproduction	--	--	--	--	--	--	--	--
Saplings	21.4	1.8	24.4	--	--	--	--	--
Small poles	29.9	3.5	37.3	--	--	1.5	--	--
Large poles	9.10	4.0	52.0	--	--	.5	--	--
Small sawtimber	4.10	4.0	63.7	--	--	1.1	--	--
Medium sawtimber	.38	.7	12.7	--	--	.4	--	--
Large sawtimber	.06	.3	7.6	--	--	.1	--	--
Total	124.94	14.3	197.7	--	--	3.6	--	--
ALLIGATOR JUNIPER								
Reproduction	17.3	--	--	--	--	--	--	--
Saplings	28.5	0.6	2.8	--	--	--	--	--
Small poles	6.09	.6	6.5	--	--	0.5	--	--
Large poles	.96	.3	5.6	--	--	.2	--	--
Small sawtimber	.76	.9	12.6	--	--	-.1	--	--
Medium sawtimber	.45	1.1	12.5	--	--	.3	--	--
Large sawtimber	1.40	9.9	69.6	--	--	.1	--	--
Total	55.46	13.4	109.6	--	--	1.0	--	--

[1] Size class refers to a diameter range and not to specific products.

[2] Growth rate is the difference between ingrowth and outgrowth in a diameter class.

Forest Biology Research

(In cooperation with the Fish and Wildlife Service, U. S. Department of the Interior)

Deer mouse populations fluctuate on livestock winter range

Deer mice (above; Peromyscus maniculatus), the most common small mammals on eight sampled watersheds on the Badger Wash Experimental Area in western Colorado, were more abundant in 1963 than in 1962. In May 1963, 176 deer mice were taken in 1,440 trap nights, compared with only 38 animals in 1962.

The catch figures depict annual population fluctuations on the experimental watersheds, with four relative highs (1957, 1958, 1960, and 1963) and three lows (1959, 1961, and 1962). The sampling shows no marked difference, however, in population trends for deer mice on the ungrazed, or protected, watersheds as compared with grazed, except for the two high-population years of 1960 and 1963. In these years, the catch was somewhat higher on the ungrazed watersheds. From the standpoint of animal population pressure, however, the use of vegetation by deer mice has not been substantially greater on the ungrazed watersheds than on the grazed.

The number of deer mice caught on permanent snap-trap lines in mid-May, 1957-63, with 720 trap-nights in each watershed treatment (ungrazed and grazed) is shown below:

	Ungrazed (Number)	Grazed (Number)	Total (Number)
1957	79	70	149
1958	68	96	164
1959	18	20	38
1960	102	71	173
1961	12	23	35
1962	22	16	38
1963	112	64	176
	413	360	773

The salt-desert shrub type at Badger Wash is used as winter range for sheep and cattle. Four watersheds were fenced in 1953 to protect them from livestock grazing. Hence, they had 4 years of protection before this small-mammal population study began.

Temperatures of pocket gopher burrows recorded

Temperatures in burrows of mountain pocket gophers (Thomomys talpoides) ranged from a low of 32°F. in winter to 71°F. in midsummer on Black Mesa in western Colorado.

Temperatures in pocket gopher burrows 4 to 8 inches belowground and covered with a

36-inch snowpack ranged from 34° to 38° in early February. In March beneath a 44-inch pack, the temperature ranged from 32° to 37°, and in April under a 29-inch receding snowpack, 38° to 44°.

Summer temperatures were recorded at various dates in July, August, and September. Extremes were measured in July: the lowest burrow reading was 41° (a nighttime minimum) and highest, 71° (a daytime maximum). August and September readings fell within these extremes.

Pocket gophers utilize "wormer" portion of snowpack

Mountain pocket gophers make use of the snowpack for travel and feeding on above-ground vegetation in winter. They also deposit cores of soil in the pack as they clean and extend their belowground burrow systems. Snow tunnels have been observed at ground line and up as high as 15 inches in the snowpack (fig. B-1).

Snowpack temperatures were read at 6-inch intervals from the ground line to the top of the pack (fig. B-2). Within the zone of the snow mantle in which pocket gopher activity was observed -- from ground line up to 18 inches -- temperatures ranged from 33°F. to 28°F. At ground line the range was from 31° to 33°; 18 inches up in the pack, the range was from 28° to 31°. Above 18 inches, temperature readings were usually below 30°. These observations and temperature readings show that pocket gophers confine their use of the snow mantle to the lower portion with the highest temperature.

Figure B-1.--A mountain pocket gopher tunnel system 10 inches aboveground in a 64-inch snowpack lies to left of the ruler, and one at ground line is visible to the right. At the extreme right is a core of soil pushed into the snow mantle from an underground burrow system.

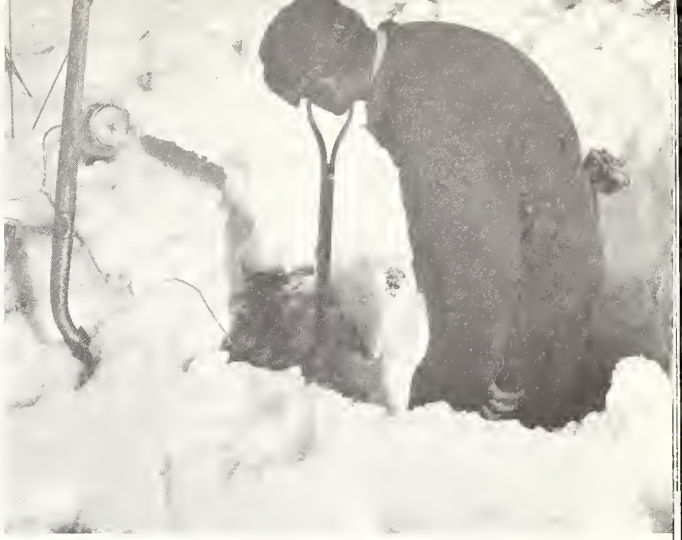


Figure B-2.--Pits were dug in the snowpack to observe pocket gopher activity and to determine the temperature of burrows belowground and in the snowpack.

Pocket gophers feed on forage plants

Mountain pocket gophers used both aboveground (fig. B-3) and belowground (fig. B-4) parts of range plants in their feeding activity on the Black Mesa Experimental Area. These observations were supported by examining the stomach contents of gophers collected from Black Mesa in summer and fall. Of the plant material found in the stomachs, about 76 percent was aboveground plant parts such as stems and leaves; the remaining 24 percent was root material.

Figure B-3.--Pocket gophers commonly feed on aboveground parts of plants in summer.

Clipped aspen fleabane (Erigeron macranthus Nutt.) stems to right of ruler and flower head and piece of stem in front of entrance to pocket gopher burrow system.

Clipped pieces of stem and flower heads of aspen fleabane strewn in bottom of exposed pocket gopher burrow system in July at Black Mesa.

Figure B-4.--Belowground parts of plants are stored for winter food. A food cache (top) made by pocket gopher was exposed 6 inches below surface of ground in late April during snowmelt period on Black Mesa.

The cache (center) contained common dandelion roots (Taraxacum officinale Wiggers) and corms of purple oniongrass (Melica spectabilis Scribn.). Pocket gopher (bottom) trapped from burrow system with the food cache.

Pocket gophers more abundant in 1963 than 1962

In 1963, the average number of mountain pocket gophers per acre at Black Mesa was 21, compared with 14 in 1962. The increase in 1963 was attributed to better reproductive success and rearing of young in 1963, as compared with 1962. Seventy-four percent of the animals examined in 1963 were young-of-the-year. In 1962 young made up 63 percent of the sample. In 1959, on the other hand, young animals comprised only 13 percent of the population. That year, the pocket gopher population dropped from an approximate high of 29 animals per acre in 1958 to less than 5. The need, therefore, for pocket gophers to produce a good crop of young each year to maintain a high population level is apparent. Young-old ratio of pocket gophers on the Black Mesa area during August-September 1959-63 are shown below:

Year	Animals examined	Young	Old
	(Number)	(Percent)	
1959	119	13	87
1960	25	40	60
1961	54	57	43
1962	266	63	37
1963	301	74	26

Meadow vole population declining

A meadow vole (Microtus pennsylvanicus) population "crash" was in evidence in the ponderosa pine-bunchgrass vegetative type at Manitou Experimental Forest in the Colorado Front Range in the summer of 1963. A vole population peak occurred the previous year. Only three voles were taken in 3,240 trap nights in early August 1963; with the same amount of trapping effort in early August 1962, 94 voles were caught. The previous peak occurred in 1958.

Meadow voles were considered detrimental to livestock ranges, particularly during periods of peak abundance, because of the forage they consume and waste.

Range Management and Wildlife Habitat Research

Rotation grazing under moderate stocking appears best

On soil derived from limestone in the Bighorn Mountains of Wyoming, relatively heavy stocking of range units grazed in rotation substantially reduced production of Idaho fescue (Festuca idahoensis Elmer) over a 3-year period (fig. R-1). Production of fescue on soil of granitic origin, on the other hand, responded the same regardless of stocking rate or system of grazing.

As a basis for comparison, one range unit was grazed summer-long by steers at a rate aimed to utilize about 50 percent of Idaho fescue. An adjacent range, stocked at the same rate as the season-long range, contained three units that were grazed in rotation. A third range was stocked 1-1/2 times as heavily as the other two, and its three units also were grazed in rotation. The two soils were present on each range.

Steers made highest daily gains under rotation grazing at the moderate rate, and the least under rotation grazing at the heavy rate over the 1959-61 period. Average weight gains per day per animal were as follows:

Kind of management	Average daily gain (Pounds)
Rotation grazing - moderate stocking	2.09
Season-long grazing - moderate stocking	1.88
Rotation grazing - heavy stocking	1.74

At the end of the first 3-year rotation, rotation grazing at the moderate rate appears best when we consider both range maintenance and cattle weight gains. Season-long grazing at the moderate rate appears next best, and rotation grazing at the heavy rate the least desirable. The study will continue through additional rotations before final conclusions are drawn.

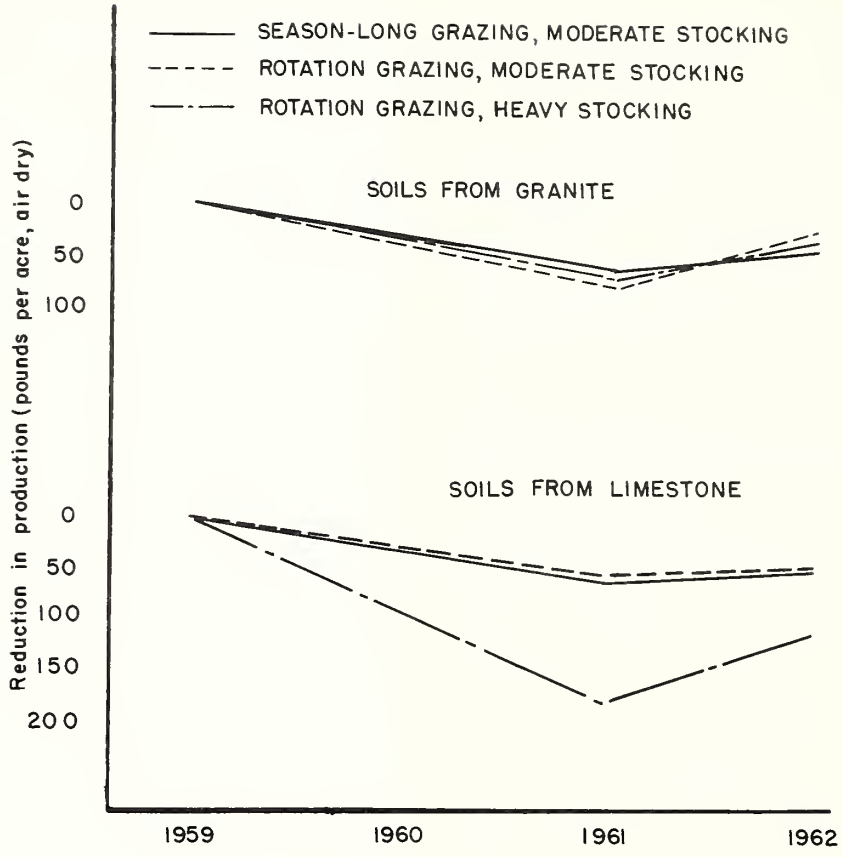


Figure R-1.--Reduction in Idaho fescue production from 1959 to 1962 on two soils and under three grazing systems, Bighorn Mountains, Wyoming.

Table R-1. --Changes in production of Idaho fescue and Thurber fescue between 1954-56 and 1962 and in their contribution to total grass yield, Black Mesa Experimental Forest and Range, Colorado

Grazing intensity and pasture number	Changes in production		Changes in contribution to total grass yield	
	Idaho fescue	Thurber fescue	Idaho fescue	Thurber fescue
	Pounds per acre		Percent	
Lightest				
2	+ 84	- 15	- 2	- 5
4	+ 95	+ 6	+ 7	- 5
Intermediate				
1	+ 98	- 69	+ 3	-14
6	+ 80	-136	+12	-15
Heaviest				
3	+126	- 97	+18	-13
5	+151	- 17	+19	- 8

Figure R-2.--Herbage production in this lightly stocked pasture on Black Mesa in western Colorado was over 1,400 pounds per acre in 1962.

Idaho fescue increases while Thurber fescue decreases

Relative production of important grasses and forbs changed considerably during 5 years of grazing at different intensities on mountain grassland range on Black Mesa in western Colorado. Under summer-long grazing that approached goals of 25, 40, and 55 percent use of Idaho fescue herbage, the proportion of grass produced by Idaho fescue increased an average of 18 percent under the heaviest rate, 8 percent under the intermediate rate, and 3 percent under the lightest rate. Production of this species in 1962, an excellent forage year (fig. R-2), was 84 to 150 pounds per acre higher than the average during the calibration period (table R-1). Greatest actual increase in production also was in the most heavily grazed pastures.

The proportion of grass produced by Thurber fescue (Festuca thurberi Vasey) was less in all pastures in 1962 than in 1954-56, and its actual production was less in five of the six pastures. Causes of the decline in production of Thurber fescue and the accompanying increase in Idaho fescue are as yet unexplained.

The combined production of six abundant forbs, agoseris (Agoseris spp.), hairy goldaster (Chrysopsis villosa (Pursh) Nutt.), aspen fleabane (Erigeron macranthus Nutt.), Fremont geranium (Geranium fremontii Torr.), aspen peavine (Lathyrus laetivirens Greene), and beauty cinquefoil (Potentilla pulcherrima Lehm.), in 1962 was greater than during the 1954-56 period by 36 percent in the most lightly grazed units, and 89 and 90 percent, respectively, in the units grazed at the intermediate and heaviest rates.

The pastures were grazed by steers from about July 15 to October 1 each year from 1954 to 1962.

Recammend 65-70 percent utilization of crested wheatgrass an spring cattle range

Sixty-five to 70 percent use of crested wheatgrass (Agropyron desertorum (Fisch.) Schult.) based on weight of herbage produced, is recommended for grazing spring cattle range in northern New Mexico. These and other findings are summarized in U.S. Department of Agriculture Production Research Report No. 74 entitled "Cattle gains and plant responses from spring cattle grazing on crested wheatgrass in northern New Mexico."

Under 65 to 70 percent utilization, crested wheatgrass was maintained in productive condition and weight gains of calves and yearlings were satisfactory. Cows were affected by grazing intensity, but, even so, they made ample gains under the recommended rate.

Crested wheatgrass makes summer and fall growth after spring grazing is completed in northern New Mexico. This regrowth helps maintain vigor of plants heavily grazed in the spring.

Stacking influences grazing time on crested wheatgrass lambing range

On crested wheatgrass lambing range in northern New Mexico, rate of stocking influenced the amount of time ewes spent grazing and resting. The animals grazed longer and more frequently in 5-acre paddocks stocked at 5.8 sheep-months per acre than in those stocked at 2.2 sheep-months per acre (fig. R-3). When managing crested wheatgrass for

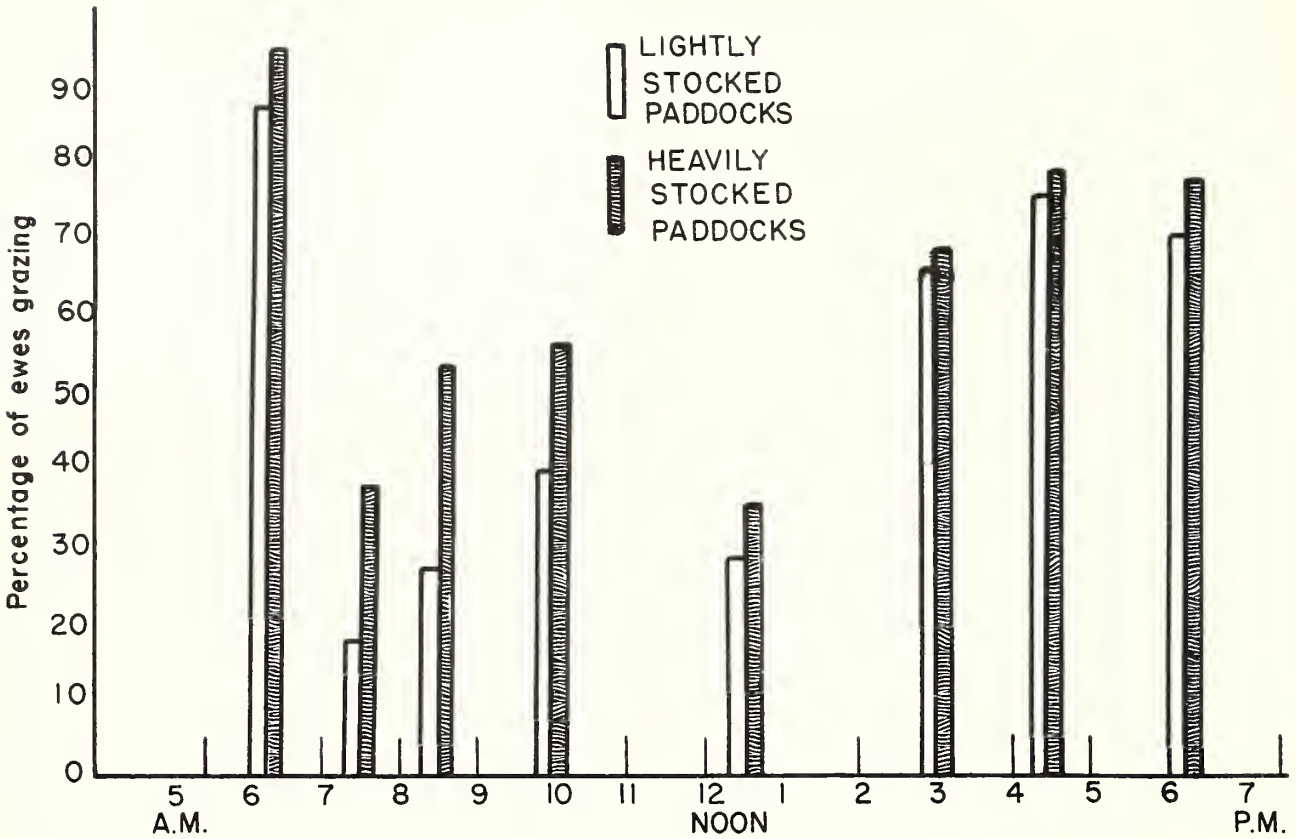


Figure R-3.--Percentage of ewes grazing at various periods from 5:30 a.m. to 7:30 p.m. in lightly and heavily stocked paddocks.

lambing, therefore, ample forage should be available; otherwise, the animals may spend too much time grazing and too little time resting and ruminating.

Principal grazing periods were from 5:30 to 7:00 a.m. and from 3:00 to 7:00 p.m. From 7:00 a.m. to 2:00 p.m. the sheep rested much of the time (fig. R-4).

Restriction of sheep to paddocks also influenced their activities as compared with those on a surrounding 200-acre range (table R-2). From 7:45 to 9:00 a.m., fewer sheep were grazing and more were resting inside the paddocks than on the large open area. From 3:00 to 4:15 p.m., however, sheep in the paddocks and on the open range spent about the same amount of time grazing.

Table R-2. --Percentage of time spent by ewes at various activities within 5-acre paddocks and on a surrounding 200-acre crested wheatgrass range in northern New Mexico

Activity	Paddocks	Open stand
	-- Percent --	
7:45 - 9:00 a.m.:		
Grazing	13.6	53.5
Browsing	.7	1.0
Resting	73.5	26.3
Traveling	10.2	13.1
At water	2.0	6.1
At salt	0	0
3:00 - 4:15 p.m.:		
Grazing	64.8	67.1
Browsing	.5	.4
Resting	20.5	5.9
Traveling	13.2	25.2
At water	0	1.4
At salt	1.0	0

Grazing was concentrated between 5:30 to 7:00 a.m. and from 3:00 to 7:00 p.m.

Sheep rested much of the time from 7:00 a.m. to 2:00 p.m.

Figure R-4.--Sheep on crested wheatgrass lambing range in northern New Mexico.

Annual grasses undependable as forage source on southwestern grass-shrub range

The forage outlook changes greatly from year to year on semidesert grass-shrub range in southern Arizona (fig. R-5). From 1957 through 1962 average grass production of six low-elevation pastures on the Santa Rita Experimental Range varied from 31 to 334 pounds per acre. Greatest fluctuation was in annual grasses. Their yields ranged from 14 to 272 pounds per acre, while those of perennial grasses ranged from 17 to 78 pounds (fig. R-6).

Annual grasses thrived in 1958, 1959, and 1961 when summer rainfall was abundant. In dry years they produced little if any more herbage than perennial grasses. Their value as forage during dry years, however, was considerably less than that of perennial grasses because of their low stature, scattered occurrence, greater susceptibility to weathering, and poor nutritive quality.

Even though perennial grasses produced only 27 percent of the total grass herbage during the 6-year period, they provided a more dependable source of forage than did annuals.

Figure R-5.--Annual grasses thrive during a wet year on the Santa Rita Experimental Range, but produce little usable herbage during a dry year.

Wet year

Dry year

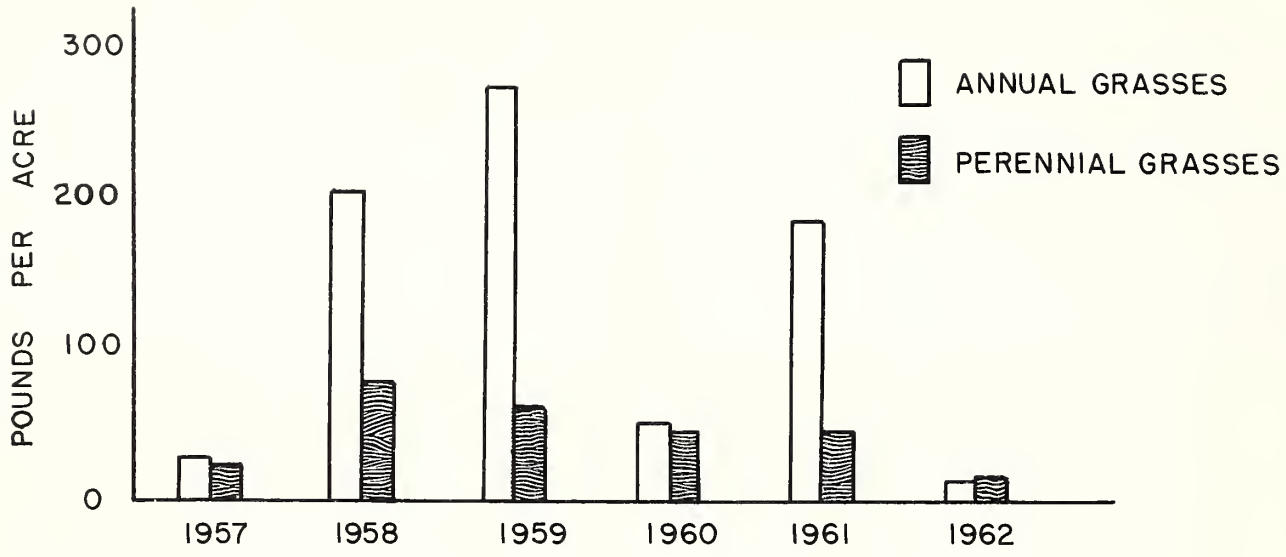


Figure R-6.--Comparative production of annual and perennial grasses on low-rainfall grass-shrub range, Santa Rita Experimental Range, Arizona.

Formula useful in predicting grazing capacity

A useful formula has been developed for estimating the number of cattle to place on a range to obtain the desired utilization. The formula is:

$$U = a + b_1\frac{1}{p} + b_2\frac{1}{s}$$

where U is the observed utilization in percent, p is the production in pounds per acre of the principal forage species or class, s is the stocking during the period expressed in acres per animal unit, and a, b_1, and b_2 are constants derived in computation of the multiple regression.

This formula, or variations of it, has provided a reliable guide for stocking experimental areas. Close relationship of the variables involved is shown by the high multiple correlation coefficients obtained at several locations. For example:

On crested wheatgrass range in northern New Mexico (based on 7 years' data).

Area	Multiple correlation coefficient
Pasture A	0.974
Pasture B	.978
Pasture C	.986
All data combined	.978

On semidesert range in southern New Mexico (based on 15 years' data).

Pasture size (Acres)	Multiple correlation coefficient based on: Black grama alone	All grasses
83,961	0.978	0.979
29,512	.947	.946
1,780	.971	.974
3,172	.979	.976
7,172	.956	.962

The procedure to date has been used entirely in experiments. It is proposed for testing as a means of estimating grazing capacity on range allotments or other administrative units.

Plant cover and topography affect deer and elk use of pinyon-juniper

Deer and elk prefer similar habitats in pinyon-juniper woodland in southern New Mexico, according to findings on a 10,250-acre area at Fort Bayard near Silver City (fig. R-7). Both deer and elk preferred areas with a moderately dense cover of trees, abundant shrubs, and a northeast exposure. Areas on which birchleaf cercocarpus (Cercocarpus betuloides Nutt.) was growing were especially preferred.

Figure R-7.--Pinyon-juniper woodland such as this provides forage and cover for deer, elk, and livestock. How to manage it for maximum benefit to ranchers and hunters is the object of a new study at Fort Bayard, New Mexico.

Slopes of 16 to 40 percent were used at least as much as more gentle slopes. In fact, pellet counts indicated relatively little use of level areas. Preference for exposure, next to northeast, was for southeast, southwest and northwest slopes, respectively, in descending order. Slope and exposure are believed to be secondary to plant cover, however, in influencing deer and elk use of pinyon-juniper woodland.

Chaparral fire-sprouts attract deer

Whitetail deer used recently burned-over areas in chaparral more than twice as much as adjacent unburned areas on the Sierra Ancha Experimental Forest in central Arizona. Fire sprouts were browsed most heavily during the late spring drought in May, June, and early July. Of the four species measured, Wright silktassel (Garrya wrightii Torr.) and birchleaf cercocarpus were preferred to shrub live oak (Quercus turbinella Greene) and Emory Oak (Q. emoryi Torr.). Pellet groups were counted within control-burned strips 50, 100, and 200 feet wide in dense chaparral, and on adjacent unburned areas. Deer habitat may thus be improved by creating 5-acre openings through controlled burning in dense Arizona chaparral, especially where Wright silktassel and birchleaf cercocarpus make up a large proportion of the cover.

Bitterbrush planted in Black Hills
graws well after heavy initial mortality

Bitterbrush (Purshia tridentata (Pursh) DC.) may become an important source of deer browse in the Black Hills if survival of young plants during their first 2 years can be improved. Few plants that survived that period have died, and surviving plants have outgrown several native browse species.

On two planting sites, one near Mystic in an open stand of mature ponderosa pine (Pinus ponderosa Lawson) and the other on the McVey burn, mortality of seedlings during the first two growing seasons (1958-59) ranged from 59 to 87 percent (fig. R-8). During the next three growing seasons, however, only 2 to 15 percent of the young plants died. Mortality of both seedlings and transplants was higher under pine than on the old burn.

At the end of the fifth growing season, survival was highest (29 percent) among transplants on the burned-over area, and lowest (11 percent) among plants direct-seeded under pine.

Both sites were cleared of herbaceous vegetation prior to planting, but no attempt was made to control competition thereafter. The cause of the heavy mortality of transplants during their second year in the field is not known.

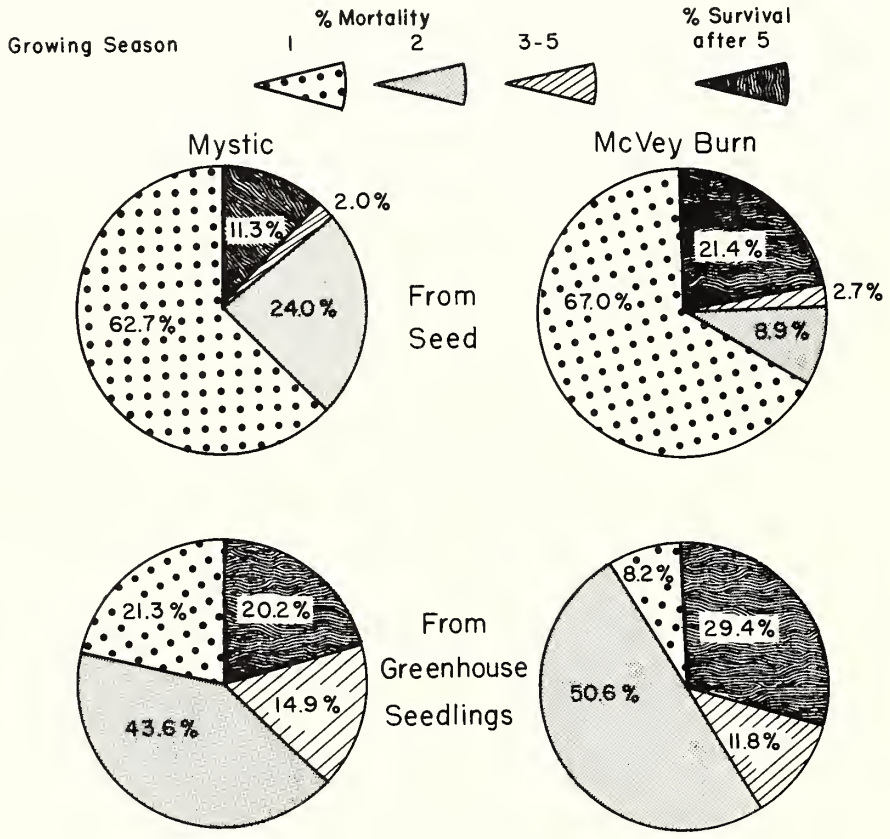


Figure R-8.--Progressive mortality of bitterbrush (Purshia tridentata (Pursh) DC.) plantings during a 5-year period (1958-62) on an open pine site near Mystic and on the McVey burn, in the central Black Hills of South Dakota.

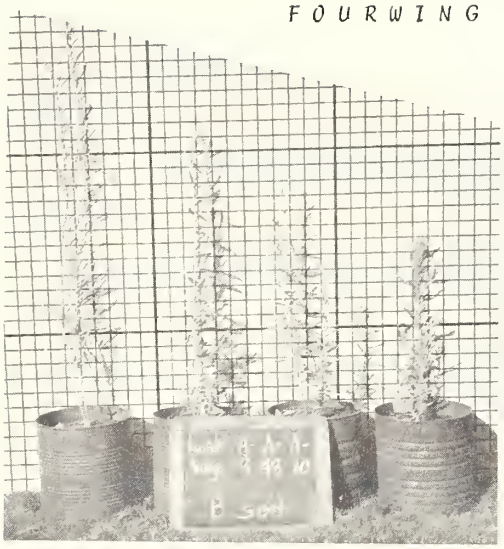


Figure R-9.--Three-month-old plants grown from seed collected from (left to right) Lordsburg, Rincon Blanco, and Corona, New Mexico, and from Delta, Colorado. Soil is a silt loam.

Figure R-10.--Plants grown in soil classified as (left to right) loam, silt loam, sandy loam, and silt loam. Seeds were collected near Corona, New Mexico.

Growth of fourwing soltbush (chomizo) vories with seed-source ond soil texture

In a comparison of effects of seed source and soil texture on growth of fourwing saltbush (Atriplex canescens (Pursh) Nutt.) at Albuquerque, New Mexico, the tallest plants developed from seed collected near Lordsburg, New Mexico, and in soil classified as a sandy loam. (figs. R-9, R-10).

As shown below, average heights of 3-month-old seedlings differed as much as 11 inches among seed sources and 7 inches among soils.

	Plant height (Inches)
Seed source:	
Lordsburg, New Mexico	26.0
Rincon Blanco, New Mexico	19.5
Corona, New Mexico	18.8
Tuba City, Arizona	18.0
Delta, Colorado	15.0
Soil texture:	
Sandy loam	23.5
Loam	22.0
Silt loam No. 1	17.7
Silt loam No. 2	16.6

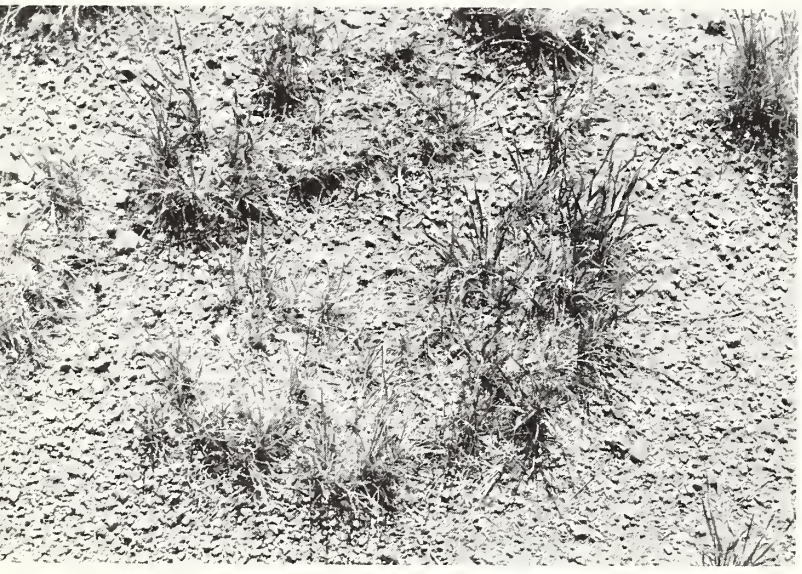
Fourwing saltbush appears promising for increasing browse for game and livestock. Studies are underway to determine growth requirements and methods of establishing the species on deteriorated pinyon-juniper rangelands in New Mexico, Arizona, and Colorado.

Shermon big bluegrass grows well during drought

Sherman big bluegrass (Poa ampla Merr.) grew taller and produced more seedstalks than other seeded grasses during the extremely dry spring and early summer of 1963 at Manitou Experimental Forest in Colorado (fig. R-11). Near the beginning of the growing season in late March, maximum leaf heights of big bluegrass, crested wheatgrass (Agropyron cristatum (L.) Gaertn.) and Russian wildrye (Elymus junceus Fisch.) averaged 4.5 inches, 2.6 inches, and 2.8 inches, respectively. By mid-May big bluegrass was 6.6 inches tall and had started to produce seedstalks. Crested wheatgrass and Russian wildrye both averaged 3.1 inches in height and showed no signs of flowering. Big bluegrass continued to grow through June until its leaves reached maximum length of 10 inches, about 6 inches longer than those of the other species (table R-3).

Figure R-11.--Comparative growth of three seeded species during severe drought, Manitou Experimental Forest, Colorado. All plants had been grazed moderately in 1962; were ungrazed when photographed on June 27, 1963.

Sherman big bluegrass



Crested wheatgrass

Russian wildrye

Table R-3. --Leaf height and seedstalk production of three seeded species, Manitou Experimental Forest, June 27, 1963

Species	Average maximum leaf height	Plants with seedstalks	Seedstalks per plant	
			Average	Maximum
	Inches	Percent	Number	
Sherman big bluegrass	10.02	82	7.13	41
Crested wheatgrass	4.45	3	.04	2
Russian wildrye	4.69	8	.10	3

This growth was made even though total precipitation was only 3.60 inches from January 1 to June 30, about half the amount normally received (6.84 inches). No moisture fell during April, and only 0.20 inch during May.

The ability of big bluegrass to produce during dry periods further enhances its value for seeding deteriorated ponderosa pine-bunchgrass ranges in Colorado. The bluegrass has the longest period with green herbage of all the grasses tested to date in the area. The herbage remains green and succulent when native bunchgrasses have become dry and lost much of their nutritive value.

Herbicidal control of chaparral after wildfire increases weeping lovegrass

Production of weeping lovegrass (Eragrostis curvula (Schrad.) Nees) in 1962 averaged 900 pounds per acre where chaparral sprouts had been sprayed with herbicide for four consecutive years after the Mingus Mountain fire of 1956 in central Arizona, compared with 75 pounds per acre on a nearby area that had been burned but not sprayed. Native grasses produced very little forage on either area (fig. R-12). Lovegrass was seeded immediately after the fire.

Though repeated spraying with herbicide is costly, it effectively suppressed the growth of sprouting shrubs. The herbicides, 2,4,5-trichlorophenoxyacetic acid and 2-2,4,5-trichlorophenoxypropionic acid, were aerially sprayed each year at the rate of 1.67 pounds acid equivalent per acre in 10 gallons of 12.5 percent diesel oil-water emulsion. Spraying was done by the University of Arizona, a cooperator in the study.

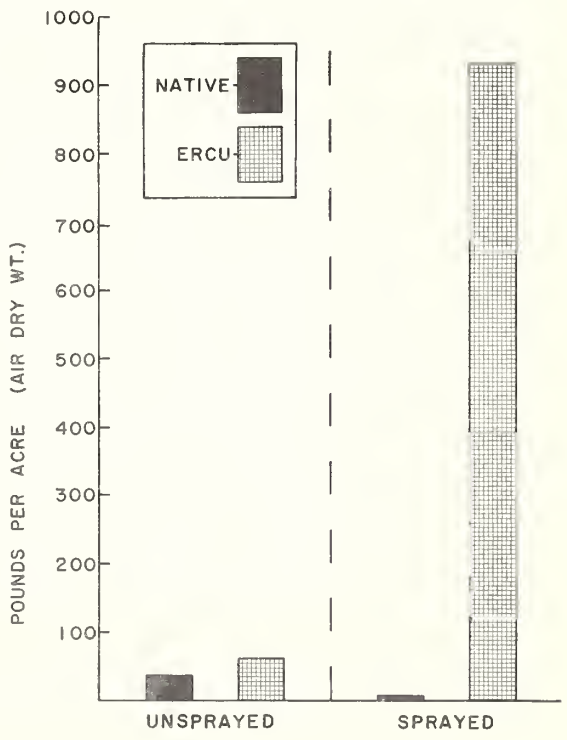


Figure R-12.--Released from competition with sprouting shrubs after wildfire and herbicide spraying in Arizona chaparral, weeping lovegrass (ERCU) produced over 900 pounds per acre. Production of the sparse cover of native grasses failed to increase, possibly because of competition with the seeded lovegrass.

Two species of willow ore dying in the Block Hills

Of 20 species and varieties of willow (Salix spp.) in the Black Hills of South Dakota, 8 are rare, 3 moderately abundant, and 9 abundant and widespread. Of the 20 kinds, 2 are dying out: Bebb willow (S. bebbiana Sarg.) and Scouler willow (S. scouleriana Barratt). Both these species are abundant, widespread, and valuable as deer browse; therefore, their condition is of concern to game habitat managers (fig. R-13). Causes of the widespread mortality of the Bebb willow are now being studied.

Results of studies of willows in the Black Hills and their condition are summarized in U. S. Department of Agriculture Technical Bulletin 1269, "The genus Salix (willows) in the Black Hills, South Dakota."

Germination of sedge seed is erratic

Sedges are an important constituent of high-elevation ranges in the central Rockies. Seed germination requirements of the important forage sedges are being studied to learn how to maintain and increase these valuable plants.

Seeds of some sedges germinate readily while others remain dormant regardless of artificial treatment, according to results of recent tests in Wyoming (fig. R-14). Examples of the variation encountered among four species are given in table R-4 and in figure R-15.

Seed germination of Carex egglestonii Mackenz. was high after most treatments, even distilled water. It began on the 9th day after seeds were planted and was complete by the 31st day.

In contrast, seeds of Carex atrata L. germinated poorly; germination after treatment in distilled water began on the 28th day and was complete on the 50th day after seeds were planted. Highest germination for this species was obtained by scarifying the seeds with sand, then keeping them moist with soil leachate. Seeds of Carex ebenea Rydb. responded well to several artificial treatments, both in rate and amount of germination. Carex raynoldsii Dewey seeds, on the other hand, failed to germinate under any treatment.

Continuous darkness and the use of hydrogen peroxide solution as a moisture source were highly detrimental to germination of all seeds.

Figure R-13.--Dead and dying stands of Bebb willow are being studied in the Black Hills.

Table R-4. --Germination of sedge (Carex) seeds in a greenhouse after various treatments

Treatments	Carex egglestonii	Carex ebenea	Carex atrata	Carex raynoldsii
	Percent			
Distilled water (check)	90	52	8	0
Continuous darkness	20	2	1	0
24-hour cold 36°F.	91	85	6	0
7-day cold 36°F.	94	98	10	0
30-day cold 36°F.	94	96	7	0
5 minutes in concentrated sulfuric acid	92	8	--	0
0.2 percent solution, potassium nitrate	46	74	17	0
Hydrogen peroxide	1	0	0	0
Soil leachate	86	88	19	0
Sand scarification	80	77	15	0
Sand scarification and soil leachate	87	92	31	0
Leaching (tap water)	90	99	2	0

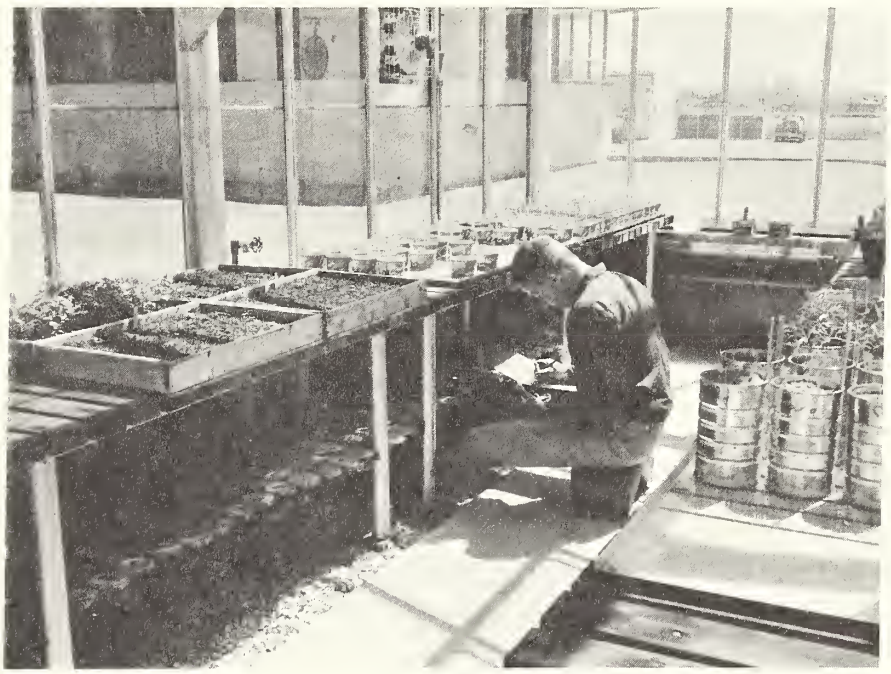


Figure R-14.-- Germination of sedge seeds varied widely among species and according to the treatment they received before being placed in a greenhouse at Laramie, Wyoming.

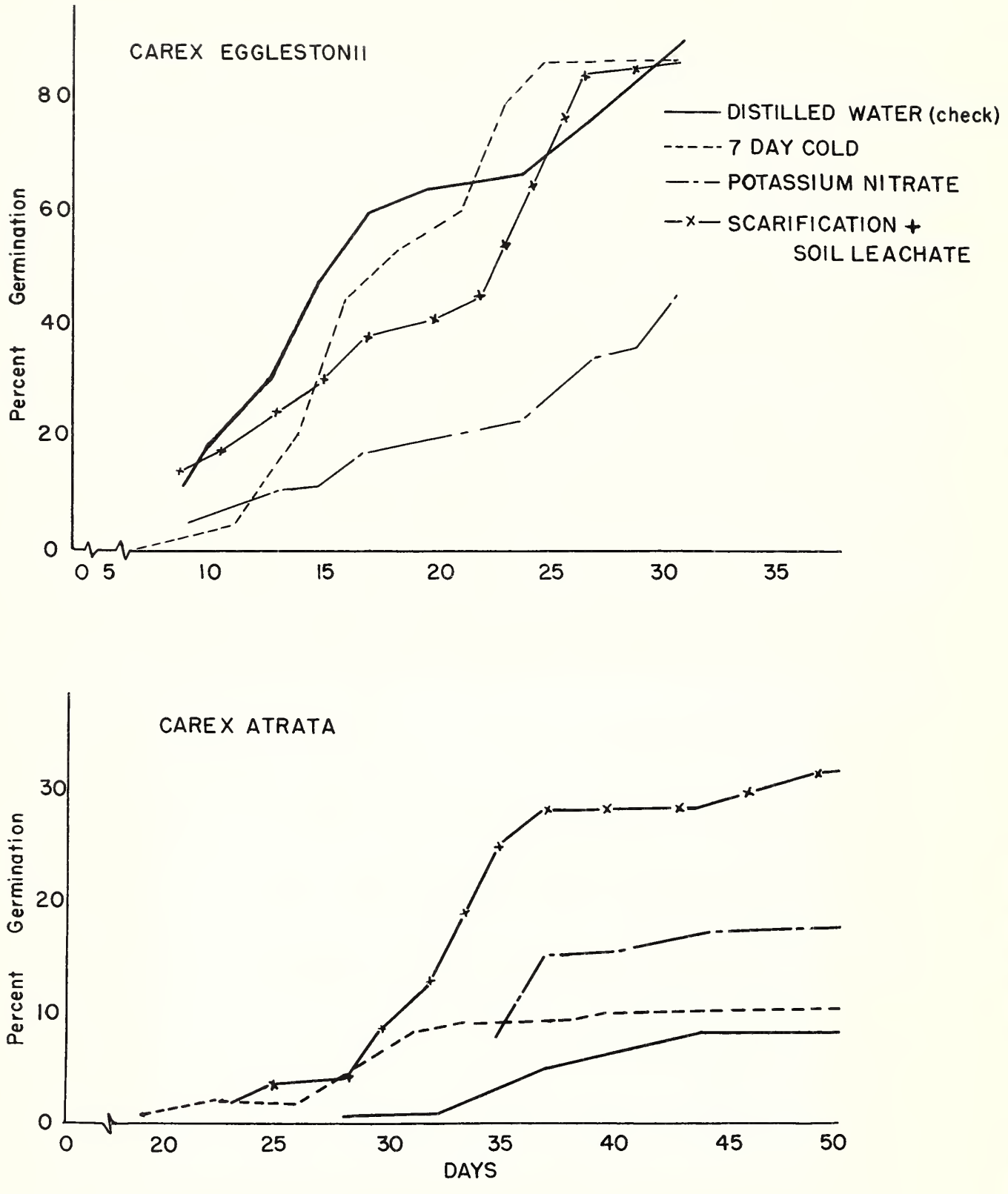


Figure R-15.--Effect of selected treatments in germination of two sedges.

Plant extracts retard growth of grass seedlings

Growth of grass seedlings in solutions containing extracts from various plants in northern Arizona was 30 to 100 percent less than growth in water only. The inhibitive effect, especially on blue grama, (Bouteloua gracilis (H.B.K.) Lag.) was more pronounced in extracts from tree leaves than from grass leaves (fig. R-16).

In the extract from Utah juniper, (Juniperus osteosperma (Torr.) Little) growth of bottlebrush squirreltail (Sitanion hystrix (Nutt.) J. G. Smith) was almost completely inhibited, and growth of blue grama seedlings was only 10 percent as much as in water only. Seedling development in extracts from pinyon (Pinus edulis Engelm.) and ponderosa pine was nearly as poor. Though blue grama made relatively good growth in extracts from grass leaves, squirreltail was severely depressed, even when grown in extract from its own leaves.

Ponderosa pine, on the average, was less affected than the grasses and grew nearly as well in extracts from leaves of woody plants as in extracts of grass plants. Arizona fescue (Festuca arizonica Vasey) was the grass most detrimental to ponderosa pine seedlings; blue grama had little effect.

These findings, though tentative, indicate that certain plants inhibit growth of some seedlings of associated plants more than others, and their control might be required before desirable forage plants can become established. They also might help to explain causes of plant succession or changes in plant composition under different range management practices.

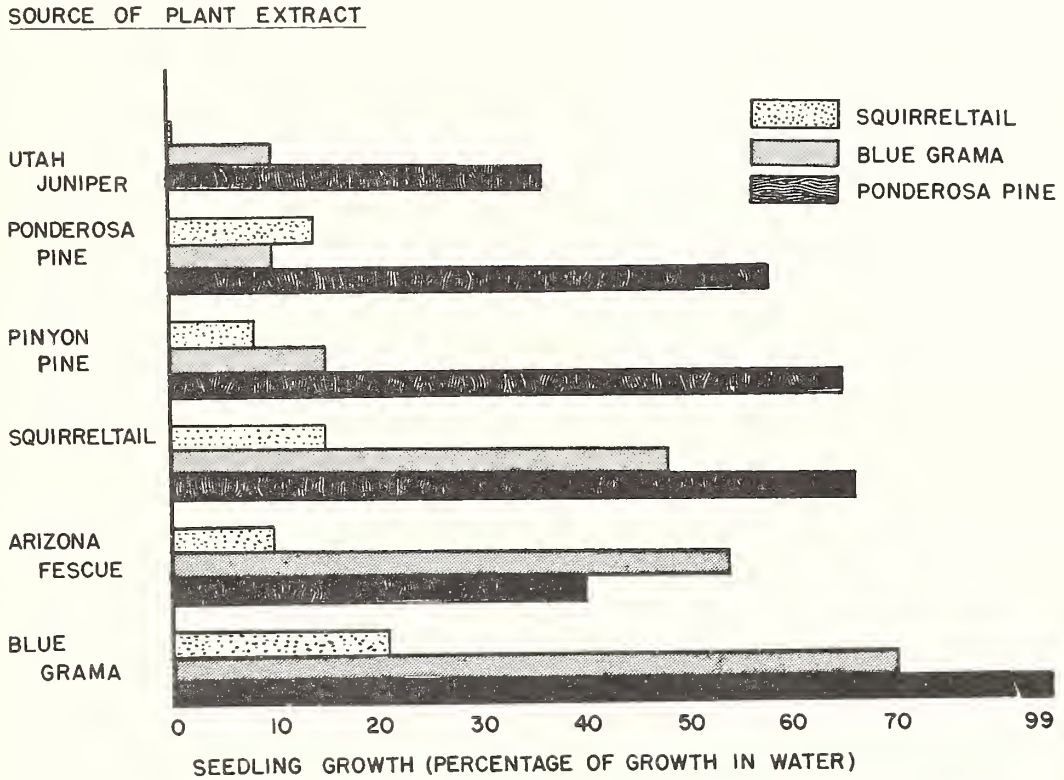


Figure R-16.--Growth of blue grama, bottlebrush squirreltail, and ponderosa pine seedling radicles in plant extract solutions, expressed as a percentage of their growth in water only.

Same shrubs seed heavily in chaparral burn

Numerous seedlings of pointleaf and Pringle manzanitas (Arctostaphylos pungens H.B. K. and A. pringlei Parry) and desert ceanothus (Ceanothus greggii A. Gray) were found after the 1956 Mingus Mountain burn in central Arizona (table R-5). Pringle manzanita was limited to the higher elevation (6,500 feet), and pointleaf manzanita was found only at the lower elevation (5,000 feet). Desert ceanothus seedlings were found at both elevations but were more numerous at the lower elevation.

Of the three prolific seeders on burns, ceanothus is a valuable deer browse, but the manzanitas are of little or no value.

Table R-5.--Number of nonsprouting shrub seedlings per acre at two elevations after the Mingus Mountain burn (1956)

Year	Pringle manzanita		Pointleaf manzanita		Desert ceanothus	
	5,000 ft.	6,500 ft.	5,000 ft.	6,500 ft.	5,000 ft.	6,500 ft.
1956	0	0	0	0	0	0
1957	0	2,860	486	0	2,748	0
1958	0	3,541	287	0	2,581	340
1960	0	3,155	239	0	4,565	272
1961	0	3,677	335	0	4,063	340

Shrub live oak vigorous after 42 years

First tagged and photographed in 1920, a shrub live oak was still alive and healthy in 1962 (fig. R-17). Vigorous young sprouts surrounded the old tagged stem, which was dead but standing. The persistence of this unpalatable shrub offers little encouragement with present control methods.

1920

1935

1962

Figure R-17.--A shrub live oak plant on the Sierra Ancha Experimental Forest in central Arizona as it appeared in 1920, 1935, and 1962. This species, commonly believed to be of low value, is long lived and, once established, persists for decades.

Watershed Management Research

Maist-site timber harvest
increases streamflow in Arizona

Water yields have increased 53 percent during the 4 years since conversion of 80 acres of moist-site forest to perennial grass, but no apparent increase in water yield has occurred during the 9 years after a selective timber harvest on an adjacent watershed.

On a 248-acre watershed (North Fork of Workman Creek) on the Sierra Ancha Experimental Forest in Arizona, 80 acres of moist-site forest--dominantly white fir (Abies concolor (Gord. & Glend.) Lindl. and Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco)--were cleared (fig. W-1)., and the area planted to perennial grass. An adjacent 318-acre watershed (South Fork of Workman Creek) was selectively logged to remove approximately 45 percent of the total basal area (fig. W-2).

The North Fork watershed is being used to evaluate changes in water yield and sedimentation resulting from changes in plant cover. The first step was to cut and poison all broadleaved trees along the stream channel. The second step was to remove and replace with perennial grass all trees (mainly Douglas-fir and white fir) growing on moist bottom sites.

South Fork is being managed for the production of high-quality timber to determine the effect such management has upon water yields and sedimentation. The first cut, in 1953, removed about 50 percent of the merchantable volume and was followed by an improvement cut to accomplish: (1) mistletoe control on pine, (2) release of pine poles by elimination of Douglas-fir and white fir, and (3) hardwood removal.

With about the same amount of timber removed from the two areas, the results indicate that harvesting of individual trees has no effect on streamflow, white clear cutting a moist-site forest can significantly increase runoff.

Figure W-1.--North Fork of Workman Creek after 80 acres of moist-site forest were cleared during September and October 1958. The area was classed as moist site wherever white fir and Douglas-fir stems 4 inches and larger made up more than 50 percent of the forest stand. Merchantable timber was removed and the remaining slash and debris arranged in contour rows and burned.

A high-mountain watershed goes on record

The production of perennial grass has probably not yet reached its potential on the North Fork conversion area. The forage measurement in 1960 indicated 500 pounds of forage per acre. This increased to 1,010 pounds per acre in 1962. Additional data will be collected from this watershed until grass production on the converted area is stable. Comparisons of water yield with increased grass cover will be made.

Twenty years ago a stream gage was built on the headwaters of East St. Louis Creek on the Colorado River side of the Continental Divide near Fraser, Colorado. Since that time, the water flowing down the creek has been recorded from just before snowmelt in the spring to the fall freezeup. During the winter, the stream trickles beneath the snow blanket at a steadily diminishing rate until the spring breakup. This steady recession rate has been

Figure W-2.--South Fork of Workman Creek after tree-selection logging, which leaves no large holes in the stand. Undesirable trees are removed as part of the treatment to favor quality tree growth. About 46 percent of the merchantable volume was removed. White fir is dominant on moist, shaded sites and ponderosa pine occupies the dry sites.

confirmed by observations during some winters, and these observations show that winter waterflow can be estimated with confidence.

The flow record is now long enough to span wet and dry years, and is worth studying to learn how high Rocky Mountain areas yield water. The stream originates in the bare, windswept, treeless, alpine zone at 12,750 feet above sea level. It tumbles down to 9,500 feet at the stream gage, flowing through dense Engelmann spruce (Picea engelmannii Parry) and lodgepole pine (Pinus contorta Dougl.) forests on the way. The total drainage area above the gage is 1,984 acres (3.1 square miles). Sixty percent of this area is above 11,000 feet elevation, (fig. W-3).

The average streamflow for the period 1943-62 has been 20.7 inches per year, or 1,100 acre-feet per square mile; 1954 was the driest year with a yield of only 12.0 inches, and 1957 was the wettest, with 30.2 inches.

That is only part of the story this stream has told. During the period May through September, 50 percent of the time flow has been more than 4 c.f.s. (cubic feet per second), but only 5 percent of the time has it been above 20 c.f.s. or below 1 c.f.s. During wet years a

Figure W-3.--A view of East St. Louis drainage basin from near the top. The stream gage is at the end of the first ridge entering on the right. The left, or west, snowcapped boundary is the lateral moraine of a former glacier. Glacial till blankets the entire valley.

larger proportion of flow comes off early, which emphasizes the importance of winter snowpack and spring precipitation.

Another important story is the rate of peak discharge and its date. This information is important to designers and operators of hydraulic structures, water users, and fish managers. Peaks from this basin come fairly late in the season--from May 30 to July 1--usually about mid-June. Peak discharges have been as low as 4 c.f.s. per square mile and as high as 26 c.f.s. per square mile.

Sagebrush-covered areas in Wyoming accumulate more snow than grasslands

To help understand the effect of sagebrush on water yield, the influence of big sagebrush (Artemisia tridentata Nutt.) on snow accumulation, snowpack profile characteristics, and snow disappearance was studied during the winter and spring of 1963 (fig. W-4). The study was conducted near Dubois, Wyoming, on sagebrush-covered experimental watersheds at about 9,500 feet on the southern flank of the Absaroka Mountain Range.

Significantly more snow accumulated on sagebrush plots than on comparable grass plots. (fig. W-5). No evidence of concrete-type soil frost or of enduring continuous sheets of ice within the snowpack was found on sagebrush-covered areas.

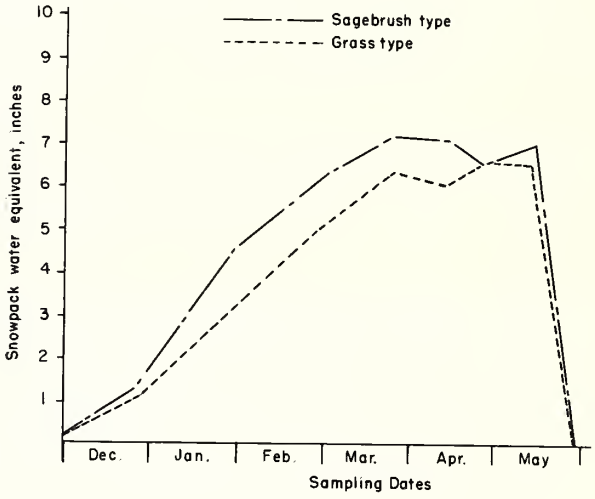


Figure W-5.--Snow-water storage in sagebrush and grass types.

On comparable grass-covered areas, less snow accumulated and continuous ice sheets were present during a major portion of the snowmelt period.

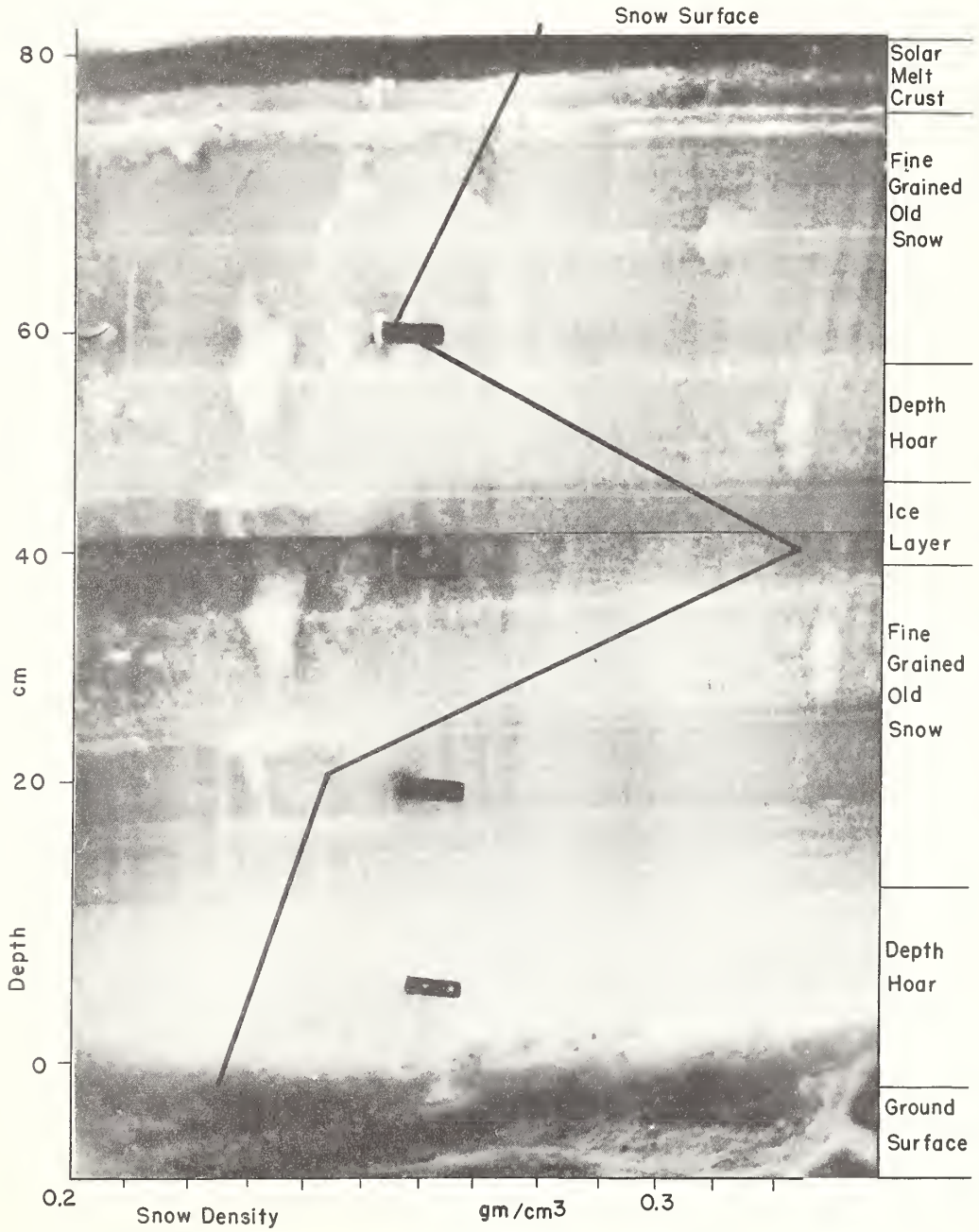
Sagebrush-covered areas retained snow longer in the spring, although melt rates were nearly the same on both types. The characteristic melt pattern in sagebrush caused by the black-body effect of the sagebrush plants may be of hydrologic significance.

Figure W-4.--A special cylindrical sampler was devised to sample snow accumulation at randomly located points over sagebrush plants, between sagebrush plants, and at various points between these extremes. The snow is removed from the sampler, weighed, and converted to inches of water. Similar measurements were made on the grass-covered plots.

Snowpock: o complex physical system

A winter snowpack is often thought to be an inert white blanket resting until it melts during the spring. The actual situation is much different. Snow crystals change their shape and arrangement continuously. Each new snowfall forms a distinct layer that develops unique properties which depend on its location in the pack (fig. W-6). Moisture migrates from layer to layer under strong temperature gradients through the snowpack.

Figure W-6.--Photograph of a cross section of the snowpack, taken March 23, 1963, shows the different characteristics of the component layers. Depth hoar is extremely loose snow crystals with low density. These crystals form as vapor moves out of a layer and the crystals reform. The ice layer at 40 cm. was formed by rain falling on the snow surface weeks before.



This change within the snowpack influences evaporation, melt rates, and strength properties that control snow avalanches.

Detailed studies of snow physics at Fraser Experimental Forest in the Colorado Rockies are revealing how the complex processes operate. This information is used in determining how forest cover influences runoff from accumulated winter snow and in developing avalanche protection.

Temperature profiles were measured through the pack (figs. W-7, W-8) by thermistors mounted on settlement disks, and associated measurements of physical properties were taken from excavations made at regular intervals. Boundary conditions were estimated by measurements of surface radiation balance made with thermal radiometers, low-level wind and temperature gradients, and soil heat-flux and temperature gradients. Net vapor transfer within and from the snowpack was then calculated.

Results reveal that water-vapor loss takes place throughout the snowpack, not just from the surface layers. The total loss from the snow was about 0.1 inch per day for clear days during March 1962.

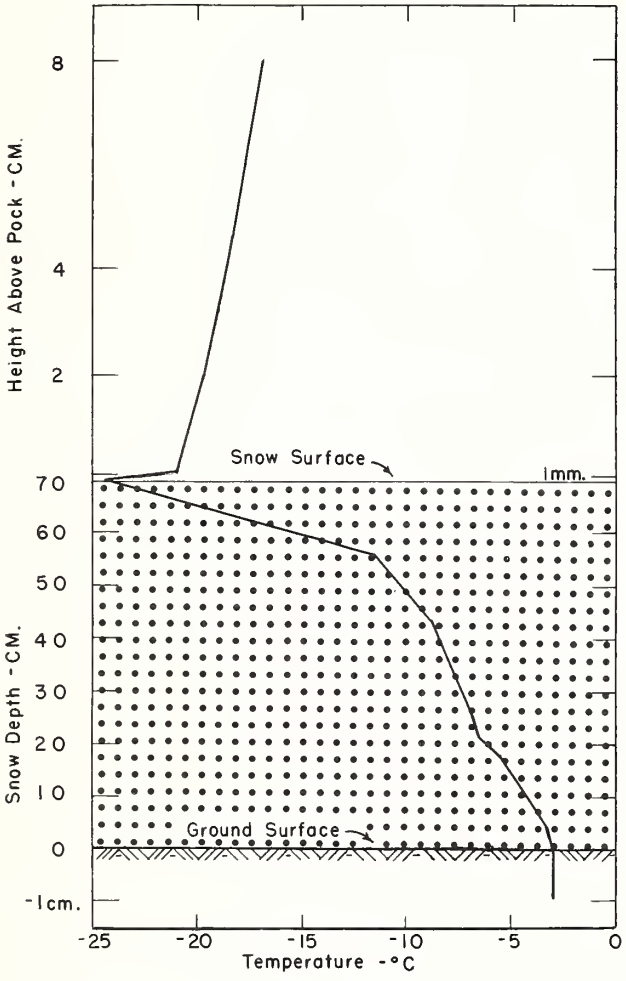


Figure W-7.--Temperature gradient from soil, through snowpack, to the air (March 10, 1963, 11 p.m.). The snow surface cools rapidly on clear nights, and chills the lower air.

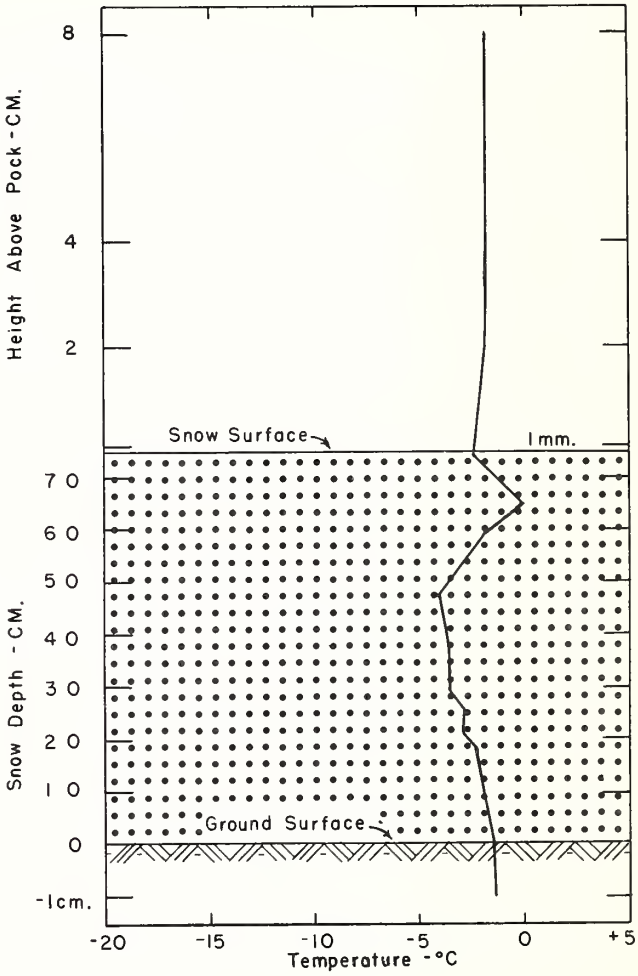


Figure W-8.--Temperature gradients are different during the day when there is warming of the snow surface. Note the temperature of the entire pack (March 22, 1963, 5 p.m.) has increased in the 12 days elapsed since March 10.

Figure W-9.--Typical canopy in pine stand thinned to 435 trees and 80 square feet basal area per acre. Canopy like this, with calculated 36 percent density in 45 degree zenith projection, intercepts about 14 percent of incoming precipitation. Subtracting that part of yearly total precipitation reaching the ground as stem flow, net loss to interception is 12 percent.

Thinning increases soil moisture under ponderosa pine

In the Black Hills of South Dakota, thinning ponderosa pine (Pinus ponderosa Lawson) stands has increased soil moisture, but only in extremely wet years does the added moisture escape tree roots to recharge ground water.

Experimental plots are located in a natural stand of 70- to 75-year-old pine with 2,335 trees per acre, and in a thinned area with 435 trees per acre (figs. W-9, W-10). Since the study started in 1958, the thinned plots have used more moisture than the unthinned because soil moisture was carried over winter to aid spring growth on the thinned plots. The thinned stand used about 2 inches more moisture than the unthinned in 1958-59. In 1960-61 it used only about 0.2 inch more moisture.

Total moisture use cannot be figured for the treatments in 1962 because the entire profiles under both treatments were fully recharged, the thinned plot by June 11-18, and the unthinned by about July 16. Moisture depletion started in both treatments near mid-July. At the end of the year there remained the following calculated amounts of available moisture in 4 1/2 feet of soil: unthinned 2.91 inches, and thinned 3.39 inches. The thinned plot was at or near full recharge 2 or 3 weeks longer than the unthinned plot, and at the end of the season still continued with one-half inch more available moisture.

Figure W-10.--Typical canopy in unthinned pine stand with 2,885 trees and 170 square feet basal area per acre. Canopy like this, with calculated 60 percent density in 45 degree zenith projection, intercepts 25 to 30 percent of precipitation. Part of this reaches the ground as stem flow; net loss to interception amounts to 22 percent of total precipitation.

Chemical controls for shrub live oak

Shrub live oak (Quercus turbinella Greene) is a major component of the chaparral complex in Arizona. This species has limited use for forage, and reduction in its abundance in selected areas would apparently favor water yield and increase useful forage production. To learn more about possible chemical control, the method of action of fenuron and 2,3,6-TBA on seedling oaks was studied by growing seedlings in treated nutrient-solution cultures.

With fenuron, visible leaf injury is evidently caused by accumulation of a toxic product of a fenuron-blocked reaction in the photosynthetic mechanism. At high fenuron concentrations, root growth is inhibited independently of the photosynthetic inhibition and its toxic product. Only slight difference was found in the development of injury symptoms to shrub live oak seedlings in low and high humidities. Thus upward movement of fenuron may not depend entirely on transpiration.

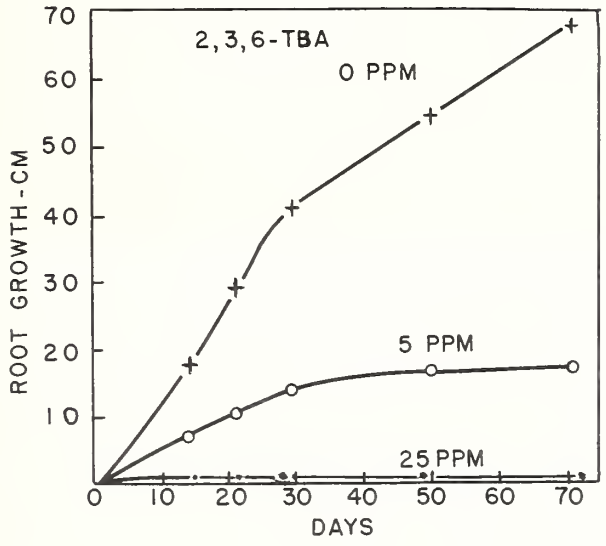


Figure W-11.--Root growth was inhibited when shrub live oak seedlings were grown in nutrient-solution cultures treated with 2,3,6-TBA.

Root-absorbed 2,3,6-TBA was a potent inhibitor of both root (fig. W-11) and shoot growth, but its killing effect was slow. Some of the seedlings that were removed from the treated solutions after 10 weeks gradually recovered. Inhibition of all seedlings and death of others occurred while the acorns were still sound, which indicates that the seedlings were unable to utilize the stored reserves for growth.

Economics of chaparral conversion

The 76-acre Three-Bar watershed C in central Arizona has been sprayed yearly by helicopter since 1960. The time and cost records provide a basis for estimating the probable expenditures required to keep the shrub canopy cover depressed to 10 percent or less. Shrub canopy cover is now approximately 7 percent, compared with 30 percent on watershed D where shrubs have been allowed to make natural regrowth following a wildfire in June 1959 (fig. W-12). Costs and benefits are as follows:

1. The average of a single spray treatment is $10.14 per acre, as shown below:

	Cost per acre
Helicopter rental	$ 4.11
Herbicide (10 gal. oil-water emulsion containing 2 lbs. acid-equivalent 2,4,5-T, and 2 gal. diesel oil per acre)	4.80
Labor (mix, load, and flag)	.71
Supervision	.24
Travel	.28
Total	$10.14

   Watershed C has been sprayed four times during the past 4 years, and eight maintenance spray treatments are anticipated during the subsequent 26 years. The total cost of 12 such spray treatments amortized at 4 percent over the 30-year period would be $266.96 per acre.

2. The average increase in water yield (over that expected on the basis of the yield from untreated watershed D) has exceeded 3 inches during the past two water years.

Figure W-12.--Unsprayed watershed: Regrowth of shrubs since 1959 wildfire is four times that on sprayed area; water yield is depressed.

Sprayed watershed: Repeated spraying has controlled shrub regrowth; water yield is higher than before the 1959 wildfire.

Assuming 3 inches of increase in water yield for a 28-year period (no increase during the first 2 years), the shrub-control treatment can be credited with 7 acre-feet of water. With a treatment cost of $266.96 per acre, the cost of additional water would be $38.14 per acre-foot.

3. The value of raw water at the weir dams is difficult to assess. However, if the increased water is given a value of $20.52 per acre-foot, and this is invested annually at 4 percent interest, the cost of the treatment ($38.14 per acre-foot) can be recovered within the same 30-year period.

The watershed was seeded by helicopter in 1960. Cost of this treatment ($6.95 per acre) and the benefits in the form of increased production and soil stabilization are not considered in the above calculations.

Tamarisk concentrates salt on its foliage

Five-stamen tamarisk (Tamarix pentandra Pall.), a water-using plant invader on wet lands, grows well where salt content is high. The plant exudes salty fluid from the leaf surfaces. Perhaps this process helps the shrubs to exist on saline sites, and it may be that this salt secretion system could be upset to aid control of this species.

For that reason the salt-excreting system was studied. Mature salt glands in five-stamen tamarisk are distinct structures composed of two vacuous and six nonvacuous cells (fig. W-13). A single pore extends from within each salt gland to the surface of the cuticular layer. Most glands are located on the dorsal leaf surfaces and on very young stems. Salt appears first as a single strand from the salt gland.

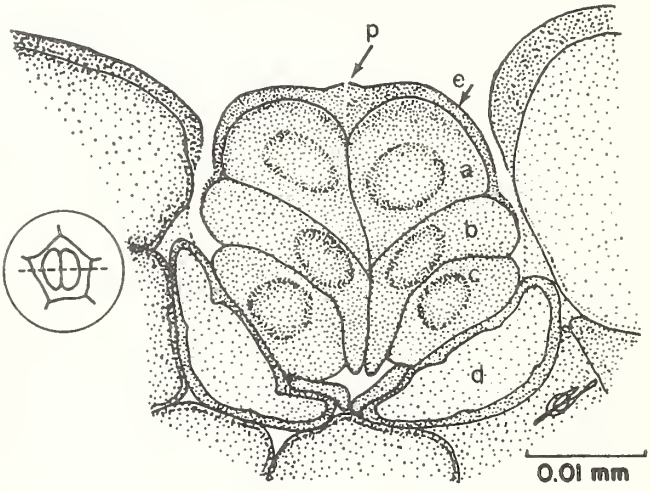


Figure W-13.--Cross section through mature salt gland, showing six cells with nuclei and granular cytoplasm; three of the cells are identified as (a,b,c). Note the location of the pore or pore space opening (p) where the pore goes through the cuticular layer (e). Directly below the three cells marked (a,b,c) is one of the two vacuous cells (d).

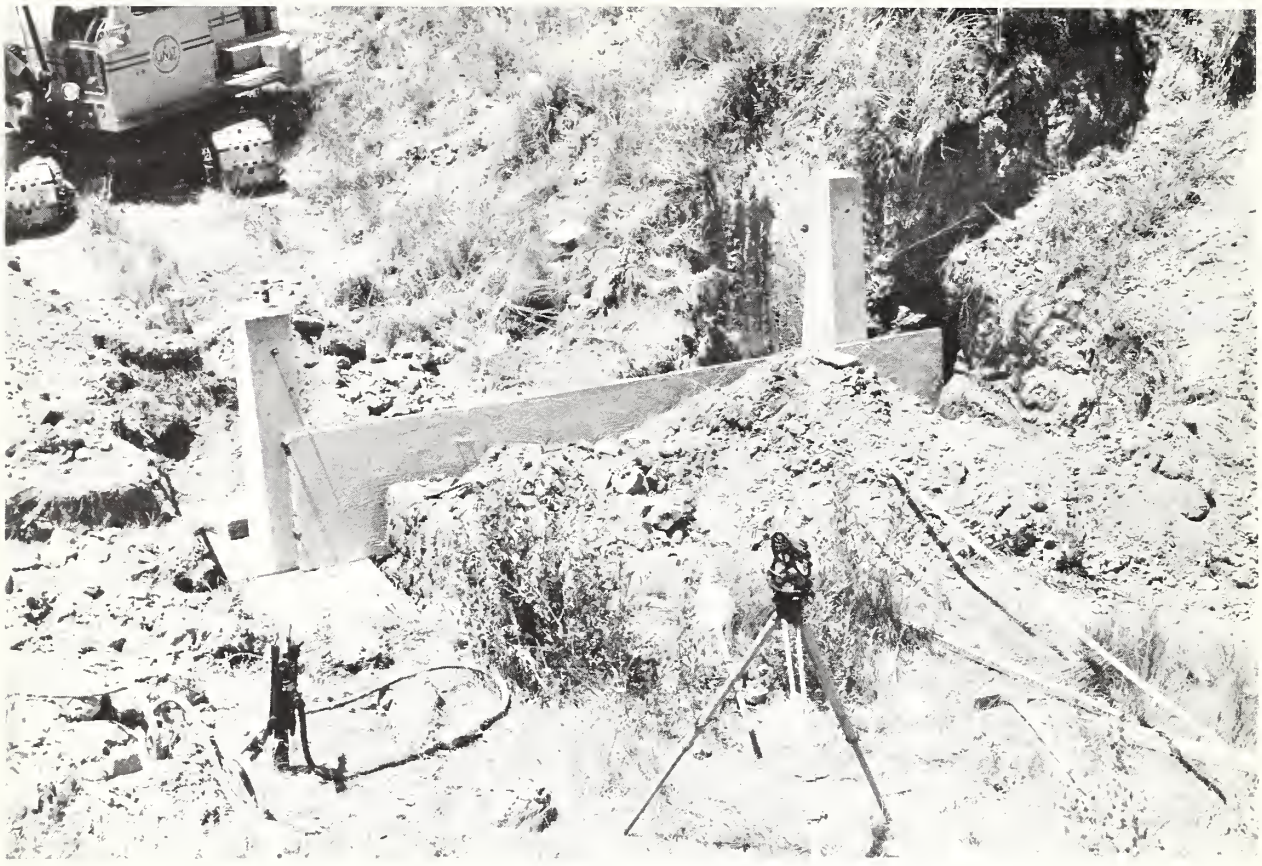


Figure W-14.--The prefab dam has a wall made of prestressed concrete slabs supported by piers set on heavy footings. The parts are set into the trench by the backhoe that does the excavation and backfilling.

Prefab concrete promising for check dams

Check dams have proven effective for gully control, but unless carefully made may be short lived. Much hand labor has been customary in their construction. Modern construction has made effective use of prefabricated concrete. For gully check dams the advantages are: (1) simple components can be designed to fit a wide range of gully sizes, (2) components can be installed with common equipment, (3) costs fall sharply with increased production, and (4) long service life can be expected.

A gravity-type structure has been designed with only three types of members (fig. W-14). The piers rest on 1-foot-thick footing slabs, which are 3 feet wide and 8 feet long. Piers and footings are made of reinforced conventional concrete. Dam wall sections are 3 inches thick and made from prestressed lightweight concrete. Small steel plates and angle irons are used to help hold the wall members rigid.

The wall is inclined 10 degrees downstream. This simplifies design and insures that the overflowing water will fall at a dis-

Figure W-15.--The downstream side of the finished dam before placement of the loose rock apron. The spillway for this dam will carry 350 cubic feet of water per second while controlling and raising the base level of the gully bottom. One machine and two men set this dam in place in 3 hours.

tance downstream from the wall. A back hoe also is used to set the dam parts in place.

The prototype is 45 feet long and 6 feet high (fig. W-15). The footing was set 1.5 feet below grade, and the sidewalls extended 4 feet into the bank. All backfill was compacted to maximum density. Steel fenceposts were driven at the downstream edge of the footing slabs to prevent sliding. The energy-dissipating apron, made from loose rock, was placed well above the bottom of the wall to prevent undercutting. The prototype dam was placed in 3 hours, not including time for excavation and backfill. There is no "hole-to-hole" fitting needed. Steel loops are attached when parts are fabricated to facilitate handling in the field. The piers are alined by eye and elevations determined by hand or engineer's level.

The design is well suited for mass production and can be easily adapted to most locations. Two piers will be enough for smaller gullies. For higher dams, greater length of foundation slabs and different positions of the piers on the foundation may be needed to prevent overturning.

Subsoil ripping reduces runoff and erosion, but may increase soil piping

A cooperative study between the Bureau of Land Management and the Forest Service, begun in 1958, shows subsoil ripping (fig. W-16) to be more effective in reducing runoff and erosion than surface pitting (fig. W-17). Precipitation, surface runoff, and eroded material were measured for 3 years on 82 runoff plots, each 310 square feet. The ripping and pitting treatments were compared on the easily eroded shale-derived soils on the Rio Puerco near Cuba, New Mexico.

For untreated soils, surface runoff was as high as 89 percent of storm rainfall, and erosion as high as 4,000 pounds of sediment per acre. Ripping reduced surface runoff 96 percent and erosion 85 percent in the first year after treatment. Three years after treatment, the reductions amounted to 85 percent for runoff and 31 percent for erosion.

Figure W-16.--The soil ripper, normally pulled by a D-8 Caterpillar tractor or equivalent, consists of two 3-foot chisels or teeth 6 feet apart. Mounted just behind each chisel is a rotating auger. Each tooth cuts a furrow about 4 inches wide and 30 inches deep. Near the bottom of the furrow, a channel about a foot in diameter is created by the action of the rotating auger.

Figure W-17.--The soil pitter consists basically of a square axle with three pentagonal "wheels," each of which has five 16-inch teeth mounted 3 feet apart. This machine may be pulled by a wheeled tractor or in series with heavier equipment. It forms pits about 16 inches deep and 8 inches in diameter, surrounded by radiating fractures.

Depressions or surface pits caused reductions of only 12 to 24 percent of surface runoff and 16 percent in erosion the first year after treatment. At the end of 3 years, surface runoff was reduced only 10 percent and erosion was about the same from treated and check plots.

On some of the ripped plots, the amount of surface runoff decreased year after year. A survey of the plots showed subterranean channels or pipes were being formed, and runoff was occurring below the surface of the ground. These pipes often finally enlarge to form open gullies.

Pipes are seen most often in areas of marine-derived shales and soils derived from them. Where soils over shale are so shallow that the ripping operation penetrates to the parent material, there is a risk of greatly increasing erosion. Such areas should not be treated by ripping.

Interception and throughfall in Utah and alligator juniper

The relation of gross precipitation and canopy density to interception was studied in the Utah and alligator juniper (Juniperus osteosperma (Torr.) Little and J. deppeana Steud.) types on Beaver Creek watershed in north-central Arizona. The canopy camera provided the best index of canopy density (fig. W-18). Interception was computed by subtracting throughfall from gross precipitation (stemflow was found to be negligible). Gross

Figure W-18.--A worm's eye view of a dense Utah juniper stand taken with a camera equipped with a hemispherical lens. A transparent dot grid overlay is used to determine the index to canopy density. The lens was about 1 foot above ground surface.

precipitation accounts for about 10 times more of the total variability in interception than does canopy density index.

For the 1 year of record, annual interception averaged 17 percent of precipitation on the Utah juniper plots, and 10 percent on the alligator juniper.

Sediment production declines after controlled grazing

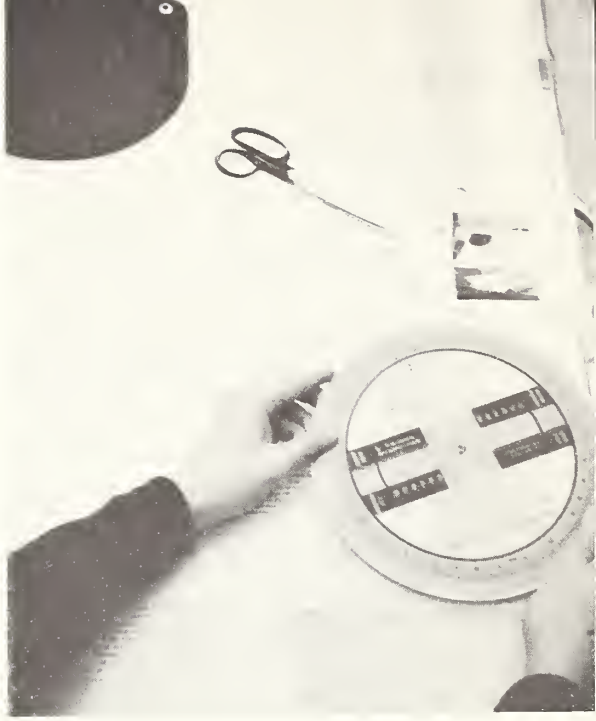
A change in livestock grazing use from yearlong to overwinter resulted in a decline in sediment production on the San Luis experimental watershed in New Mexico.

In 1952 a cooperative study was begun on the Rio Puerco drainage in New Mexico to determine the feasibility of restoring the frail, deteriorated lands of this region. Grazing management was started, but full control of the livestock by overwinter use only was not achieved until 1958. The periods of use for 1952-58 and 1959-62 have been examined to determine how this different grazing use influenced sediment yield and ground cover.

Average ground cover as measured by three key grass species--alkali sacaton (Sporobolus airoides Torr.), galleta (Hilaria jamesii (Torr.) Benth., and blue grama (Bouteloua gracilis (H.B.K.) Lag.)--increased (1959-62 period) to 9 percent from 4 percent measured in the pretreatment period (1952-58). Bare ground decreased during the 1959-62 period. Sediment production decreased between 0.2 and 0.8 acre-foot per year on the watersheds as a result of the summer deferment grazing practice. Precipitation averages between periods were similar.

Overwinter grazing, practiced under conditions of the study, should result in increased ground cover, a reduction of bare soil, and a decrease in sediment production.

Publications



FOREST INSECT RESEARCH

Hamre, R. H.

The case of the dying budworms. Denver Post, Empire Section 14 (47): 37, 39, illus.

Epidemic populations of spruce budworms damaging several hundred thousand acres of forest in Colorado suddenly collapsed in the summer of 1963. Parasitism by a tiny Bracon wasp was a primary cause of the budworm mortality.

Massey, Calvin L.

Santafea new genus (Rhabditoidea, Chambersiellidae) and a change in the systematic position of Macrolaimus Maupas 1900. Helmin. Soc. Wash. Proc. 30: 26-28, illus.

A new genus is described; the genotype is Santafea croca n. sp. The nematode was found associated with bark beetles in white fir and juniper. The genus Macrolaimus is removed from the family Cephalobidae and placed in the family Chambersiellidae.

FOREST DISEASE RESEARCH

Hawksworth, Frank G.

Black Hills ponderosa pine susceptible to southwestern dwarfmistletoe. Res. Note RM-1, 2 pp.

Climatic conditions probably account for the absence of Arceuthobium vaginatum (Willd.) Presl f. cryptopodum (Engelm.) Gill in Pinus ponderosa Lawson in the Black Hills. Small-scale greenhouse inoculations demonstrated susceptibility.

*Private, State, or Federal cooperator.

_____ and *Graham, Donald P.

Dwarfmistletoes on spruce in the western United States. Northwest. Sci. 37: 31-38, illus.

The western spruce dwarfmistletoe, Arceuthobium campylopodum f. microcarpum, is known only from Arizona and New Mexico. Other dwarfmistletoes sometimes attack spruce, and these have been the basis for the erroneous reports of the western spruce dwarfmistletoe elsewhere in the West.

_____ and *Graham, Donald P.

Spread and intensification of dwarfmistletoe in lodgepole pine reproduction. Jour. Forestry 61: 587-591, illus.

Studies of 79 plots in Montana, Wyoming, and Colorado showed that, in young stands adjacent to infected mature stands, infection ranged from 3 percent in 10-year-old stands to 32 percent in 25-year-old stands. Suggestions for control of dwarfmistletoe in lodgepole pine reproduction are given.

Hinds, Thomas E.

Extent of decay associated with Fomes igniarius sporophores in Colorado aspen. Res. Note RM-4, 4 pp.

Estimated board-foot cull for a tree with 1 to 3 sporophores at any height, or any number of sporophores 0 to 16 feet on the bole, is 59 ± 3.2 percent (20±1.6 percent cubic-foot cull). A tree with sporophores not in these two classes should be considered a total cull.

_____, Hawksworth, F. G., and *McGinnies, W. J.

Seed discharge in Arceuthobium: a photographic study. Science 140: 1236-1238, illus.

Photos of the seed-expulsion process of dwarfmistletoe at a speed of 5×10^{-6} second did not stop action completely, but gave fairly satisfactory results.

Peterson, Glenn W.

Cedar blight. In Dangerous international forest tree diseases. U. S. Dept. Agr. Misc. Pub. 939, pp. 105-106.

Concisely describes cedar blight (Phomopsis juniperovora) with particular reference to the possibilities of intercontinental spread.

_____

Going. . . going. . . going. . . gone. . . courtesy of Dutch elm disease. Nebr. Expt. Sta. Quart. 9(4): 10-11, illus.

Relates known distribution of Dutch elm disease in Nebraska and outlines a program for community-wide control.

Peterson, Roger S.

Notes on western rust fungi. III. Cronartium. Mycologia 54: 678-684.

Distribution and host records are given for Cronartium comandrae, the C. coleosporioides complex, and Peridermium mexicanum. P. mexicanum causes a distinctive lobed, stalked gall, and should not be considered synonymous with any Cronartium species until the connection is proved. Nomenclature in the C. quercuum group is reviewed, and inoculations bearing on the possible relationship of P. cerebroides are reported. (Not included in 1962 Annual Report)

_____

Spruce broom rust. In Dangerous international forest tree diseases. U.S. Dept. Agr. Misc. Pub. 939, pp. 91-92.

Concisely describes spruce broom rust (Chrysomyxa arctostaphyli) with particular reference to the possibilities of intercontinental spread.

Riffle, Jerry W.

Meloidogyne ovalis (Heteroderidae), a new species of root-knot nematode. Helmin. Soc. Wash. Proc. 30: 287-292.

A new species of root-knot nematode, Meloidogyne ovalis, is described. This nematode was found parasitizing sugar maple, American elm, and white ash. A greenhouse host range test showed that it also infests and reproduces on three other maples and two birches.

TIMBER MANAGEMENT AND FOREST FIRE RESEARCH

Alexander, Robert R.

Harvest cutting old-growth mountain spruce-fir in Colorado, Jour. Forestry 61:115-119, illus.

Three cutting methods were tested. Alternate clear-strip cutting is recommended: reproduction was more abundant and better distributed, windfall was reduced, and net increment was improved.

Boldt, Charles E.

A stand volume table for immature ponderosa pine in the Black Hills. Res. Note RM-5, 4 pp.

Two tables permit direct estimation of stand total and merchantable volume, in cubic feet per acre; sample values of basal area and average total height of dominant and codominant trees are required.

Heidmann, L. J.

Deer repellents are effective on ponderosa pine in the Southwest. Jour. Forestry 61: 53-54, illus.

Two deer repellents, TMTD and ZAC, reduced browsing of southwestern ponderosa pine seedlings from 56 percent to less than 10 percent. Both repellents were effective through one growing season only.

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Effect of rock mulch and scalping on survival of planted ponderosa pine in the Southwest. Res. Note RM-10, 7 pp., illus.

A three-rock mulch increased survival only where vegetation was undisturbed. Scalping was equally effective. Planting stock should be 0.19 inch in diameter at the root collar, and have an 8-inch, well-developed root system.

_____

Heavy pruning reduces growth of southwestern ponderosa pine. Res. Note RM-3, 4 pp.

Forty percent of the live crown was removed without reducing diameter growth. This pruning intensity left crowns equal in length to 31 percent of tree height. Sixty percent crown removal did not reduce height growth.

Larson, M. M.

Initial root development of ponderosa pine seedlings as related to germination date and size of seed. Forest Sci. 9: 456-460, illus.

Seedlings that germinated early produced larger, deeper, and heavier root systems than those that germinated later. Size of seed had little or no influence on rate of germination, germination percent, or seedling growth.

Myers, Clifford A.

Estimating volumes and diameters at breast height from stump diameters, southwestern ponderosa pine. Res. Note RM-9, 2 pp.

Describes a procedure for determining d.b.h. and volume, based on stump diameter inside bark measured 1 foot aboveground on the uphill side.

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Estimating past diameters of ponderosa pines in Arizona and New Mexico. Res. Note RM-7, 4 pp.

Past diameters can be estimated from tables presented if two measurements are known: present diameter, and radial growth of wood for any described period, both at breast height.

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Point-sampling factors for southwestern ponderosa pine. Res. Paper RM-3, 15 pp., illus.

Presents volume-basal area ratios for ponderosa pine in Arizona and New Mexico.

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Taper table for pole-size ponderosa pines in Arizona and New Mexico. Res. Note RM-8, 2 pp.

Diameter inside bark at various heights aboveground is presented as a function of d.b.h. and total tree height.

_____
Vertical distribution of annual increment in thinned ponderosa pine. Forest Sci. 9: 394-404, illus.

Before thinning, the annual layers were widest at about 80 to 85 percent of tree height and narrowest at 20 to 25 percent of tree height. During the period of most rapid growth after thinning, the layers were widest at the tree bases and narrowest at about 70 percent of tree height. By the fifth to eighth year after thinning, the layers were widest at about 85 percent of tree height and narrowest at about 25 percent of tree height.

_____
Volume, taper, and related tables for southwestern ponderosa pine. Res. Paper RM-2, 24 pp., illus.

Volume tables, taper tables, and distribution of tree volumes among logs of saw-log trees are presented. Volumes are in total cubic feet and cubic feet to a 4.0-inch top; board feet Scribner rule to a variable top, and board feet International 1/4-inch rule to a variable top. Tree heights are in feet and numbers of logs.

_____ and Martin, Edward C.
Fifty years' progress in converting virgin southwestern ponderosa pine to managed stands. Jour. Forestry 61: 583-586, illus.

Two partial harvests in uneven-aged stands reduced mortality and board-foot increment and increased cubic-foot increment in the residual stands. Future use of conventional cutting systems will lead to even-aged stands in many areas and to group-selection stands where present structure is many aged.

_____ and Martin, Edward C.
Mortality of southwestern ponderosa pine sawtimber after second partial harvest. Jour. Forestry 61: 128-130, illus.

Major causes of mortality are lightning, dwarf-mistletoe, wind, and insects. Trees larger than 30 inches d.b.h. are poorest risks; trees 12-20 inches d.b.h. are usually best risks. Mortality was less after second harvest than after first due to continued removal of largest, oldest, and least vigorous trees.

Sander, D. H.
Height-age curves for Austrian pine in windbreaks on Loess soils of Nebraska. Res. Note RM-13, 2 pp., illus.

Reports heights Austrian pines have attained at different ages on a range of sites, and a means of rating site capability or site quality.

Van Haverbeke, David F.
Root development of ponderosa pine seedlings in the Black Hills. Ecology 44: 161-165, illus.

On plots freed of all vegetation, first season's growth of pine roots was greater than two seasons' growth, and in some cases, three seasons' growth, in seed spots where vegetative competition was not completely eliminated.

FOREST UTILIZATION RESEARCH

Mueller, Lincoln A., and Barger, Roland L.
Lumber grade recovery from Engelmann spruce in Colorado. Res. Paper RM-1, 23 pp., illus.

The study reports on the yields of lumber by grade that can be expected from near-average Engelmann spruce saw logs, the losses and sawing time involved in processing logs to finished lumber, and the effectiveness of grading spruce logs by a set of trial log grades.

Woodfin, R. O. Jr.
Treating and harvesting interval for debarking ponderosa pine pulpwood with sodium arsenite. TAPPI 46(2): 73-75, illus.

Chemical debarking was successful on Black Hills ponderosa pine trees after treating with 40 percent sodium arsenite and various treating and harvesting intervals were used.

FOREST ECONOMICS RESEARCH

Hughes, Jay M.
Pulp and papermaking opportunities in west-central Colorado. TAPPI 46(2): 26A, 28A, 30A, illus.

Summarizes study of wood, water, pulpwood cost, and other factors relevant to feasibility of pulpmill establishment in west-central Colorado.

_____ and *James, Lee M.
The nation's income from timber products. Jour. Forestry 61: 185-189, illus.

Income payments in 1958 attributable to timber products industry of the United States were measured, and comparisons made with other segments of national and regional economies.

RANGE MANAGEMENT

AND WILDLIFE HABITAT RESEARCH

*Gray, James R., and Springfield, H. W.
Crested wheatgrass for lambing pays high returns. Natl. Wool Grower Mag. 53(1): 12-14, illus.

Weight gains and death losses of lambs and ewes, and forage yields were measured on crested wheatgrass ranges during a 3-year experiment in northern New Mexico.

Jameson, Donald A.
Responses of individual plants to harvesting. Bot. Rev. 29: 532-594.

Reviews literature on the responses of plants to harvesting and the physiological bases for these responses. Points out deficiencies in knowledge of the effect of harvesting on plant responses.

Martin, S. Clark.
Grow more grass! by controlling mesquite. Progressive Agr. in Ariz. 15(4): 15-16, illus.
The amount of grass produced on southern Arizona ranges is increased by removing mesquite. Yields of grass on mesquite-free study plots were from 71 to 102 pounds per inch of summer rainfall, from 7 to 12 times greater than on mesquite-infested plots.

Reid, Elbert H., Kovner, Jacob L., and Martin, S. Clark.
A proposed method of determining cattle numbers in range experiments. Jour. Range Mangt. 16: 184-187, illus.
Multiple regression formulas that relate herbage production, animal use, and forage utilization gave good estimates of grazing capacities. Four examples are given. A separate formula is derived for each pasture because each varies as to cattle distribution patterns, relative amounts of forage types, and relation of forage species measured to all forage produced and used.

Reynolds, H. G.
Western goshawk takes Abert squirrel in Arizona. Jour. Forestry 61: 839.
A positive example of predator-prey relations between the western goshawk and Abert squirrel was established. This squirrel is a pest with regard to timber management. The goshawk may be a potential regulatory mechanism.

_____
A wildlife habitat research program for the Southwest. Ariz.-N. Mex. Wildlife Soc. Proc. 2: 28-40.
A research program on wildlife habitat includes studies toward (1) determining basic habitat requirements, (2) game responses to timber, range, and watershed management activities, and (3) methods for modifying existing land-use practices to include programs beneficial to game.

_____ and *Tschirley, Fred H.
Mesquite control on southwestern rangelands. U. S. Dept. Agr. Leaflet 421, 8 pp, illus.
Mesquite, which has been increasing steadily, reduces forage production of rangeland. Removal recommendations are: Trees less than 1-inch stem diameter should be grubbed; larger trees can be killed with diesel oil or dozed. Where stands exceed 100 trees per acre, either foliage sprays or cabling and chaining are recommended.

*Shumway, R. Phil, *Hubbert, Farris, Jr., *Hayer, W. T. III, Cable, D. R., and *Hale, W. H.
A qualitative determination of the diet of grazing steers under desert grassland conditions. Amer. Soc. Anim. Sci. Proc. 14: 38(1-6), illus.
Crude protein content of clipped samples of Lehmann lovegrass and Arizona cottontop averaged 6.67 percent over a 2-year period, compared to 11.22 percent for rumen samples from fistulated steers grazed on the same area. Increased protein intake at all seasons was due to selective grazing of grasses, forbs, and shrubs.

Springfield, H. W.
Cattle gains and plant responses from spring grazing on crested wheatgrass in northern New Mexico. U. S. Dept. Agr. Prod. Res. Rpt. 74, 46 pp., illus.
Herbage yields were not affected by the different grazing intensities. Cattle gains were substantially higher on crested wheatgrass than on native range. Optimum intensity of grazing appears to be 65-70 percent utilization.

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Management: Size of grazing area affects sheep behavior. West. Livestock Jour. 41(36): 46-47.
Observations during two lambing seasons indicate sheep activities were influenced by availability of forage, weather conditions, and confinement within small pastures. (Taken from Res. Note 77, published in 1962).

_____
A seeding test with fourwing saltbush (chamiza) in western New Mexico. Res. Note RM-11, 15 pp., illus.
Two methods of seeding and four kinds of seedbeds were compared. Drilling and cultipacker-seeding were equally effective. Plant establishment was higher where a seedbed was prepared, but a fair stand was established by seeding on an unprepared seedbed.

U. S. Forest Service.
Range research methods: a symposium... May 1962. U. S. Dept. Agr. Misc. Pub. 940, 172 pp., illus.
Twenty-four papers, presented at the Range Research Methods Conference in Denver, Colorado, May 7-12, 1962, have been compiled into one publication. The following eight papers were authored or coauthored by Rocky Mountain Station personnel:

Hilmon, J. B., Clutter, J. L., and Cable, D. R. Layout of experimental units. pp. 124-131.
Hutchings, Selar S., and Pase, Charles P. Measurement of plant cover--basal, crown, leaf area. pp. 22-30.
Jameson, Donald A. Evaluation of the responses of individual plants to grazing. pp. 109-116.
Johnson, W. M., and Laycock, W. A. Kind, number, and selection of livestock for grazing studies, and animal measurements most suited for evaluating results. pp. 109-116.
Kovner, Jacob L. Some statistical problems in design and conduct of grazing experiments. pp. 148-152.
Morris, Meredith J. The use of rating or ranking in vegetation measurement. pp. 40-42.
Reynolds, Hudson G., and Packer, Paul E. Effects of trampling on soil and vegetation. pp. 116-122.
Smith, Dwight R., Currie, Pat O., Basile, Joseph V., and Frischknecht. Neil C. Methods for measuring forage utilization and differentiating use by different classes of animals. pp. 93-102.

WATERSHED MANAGEMENT RESEARCH

American Association for the Advancement of Science, Southwestern and Rocky Mountain Division
Water yield in relation to environment in the southwestern United States. Desert and Arid Zones Res. Comm. Symposium, 1960, 74 pp., illus.

Fourth in a series of symposia arranged by the Committee to encourage study and research on the phenomena affecting human occupation of arid and semiarid regions, primarily within the areas represented by the Southwestern and Rocky Mountain Division of the AAAS. Included were papers by:

Decker, John P. Relation of phreatophytes to water yield in arid environments. pp. 64-69.
Dortignac, E. J. Water yield from pinyon-juniper woodland. pp. 16-27.
Love, L. D. Water yield from mountain areas. pp. 3-15.
Rich, L. R. Water yields from the brush and oak-woodland region of Arizona. pp. 28-38.

Bergen, James D.
Vapor transport as estimated from heat flow in a Rocky Mountain snowpack. Internatl. Union Geodesy and Geophys., Internatl. Assoc. Sci. Hydrol. Snow and Ice Comm. Pub. 61, pp. 62-74, illus.

The energy balance of a snow cover in the Rocky Mountains was estimated from vertical temperature profiles and boundary data for 3 days preceding thaw. Internal transport of water vapor by buoyant convection is indicated with net losses in the regions near the soil surface and the pack surface.

Decker, John P.
An analysis and simplification of the Blaney-Criddle method for estimating evapotranspiration. Res. Note RM-2, 2 pp.

Calculations for the Blaney-Criddle method can be simplified for some applications.

Garcia, George, Hickey, Wayne, Jr., and Dortignac, E. J.
An inexpensive runoff plot. Res. Note RM-12, 8 pp., illus.

Describes construction details and costs for a simple plot to measure runoff and erosion; reports on other materials and plot shapes found less satisfactory.

Gary, Howard L.
Root distribution of five-stamen tamarisk, seepwillow, and arrowweed. Forest Sci. 9: 311-314, illus.

Describes characteristics of entire root systems hydraulically excavated from alluvial banks near the Salt River in central Arizona.

Goodell, B. C.
A reappraisal of precipitation interception by plants and attendant water loss. Jour. Soil and Water Conserv. 18: 231-234, illus.

Evaluates existing knowledge of interception of precipitation by foliage, questions validity of popular concepts, and discusses need for more analytical studies.

Hickey, Wayne C. Jr., and Garcia, George.
Tamper-proof rain gages. Res. Note RM-14, 4 pp., illus.

Two types of rain gages are described that have been designed to prevent the loss of records by vandalism.

Hoover, Marvin D.
Watershed management and water yield. In Land, Water, and People. Soil Conserv. Soc. Amer. Proc. 18: 103-108.

A discussion of Forest Service concern with watershed management, and the application of research results to managing watersheds for improved yield.

Jones, John.
Translation of "Studier over Klimatets Humiditet I Sverige" [Studies on the humidity of Sweden's climate] by Olof F. S. Tamm. U. S. Forest Serv. Translation. 42 pp., illus.

Evapotranspiration (E) in millimeters is related to mean annual temperature (T) in Centigrade degrees for the whole of Sweden by the equation $E = 115 + 28.1\ T$. The equation is useful for estimating annual streamflow, for studies of habitat, and characterizing seed source provenances.

*Lavin, Fred, and Pase, C. P.
A comparison of 16 species for seeding on chaparral burns. Res. Note RM-6, 4 pp.

Lehmann lovegrass and King Ranch bluestem were the outstanding species over three growing seasons.

Lee, Richard.
The "topographic sampler." Jour. Forestry 61: 922-923, illus.

Gives details of a simple instrument designed to obtain statistical description of a land area, with respect to slope steepness and orientation.

Lusby, Gregg C.,* Turner, George T., Thompson, J. R., and Reid, Vincent H.*
Hydrologic and biotic characteristics of grazed and ungrazed watersheds of the Badger Wash Basin in western Colorado, 1953-58. U. S. Geol. Survey Water-Supply Paper 1532-B, 72 pp., illus.

Presents data obtained during the first 5 years of a proposed 20-year study.

Price, Raymond.
Increasing water yield through research. In Conservation through research and development. West. Forestry Conf. Proc. 53: 54-57, illus.

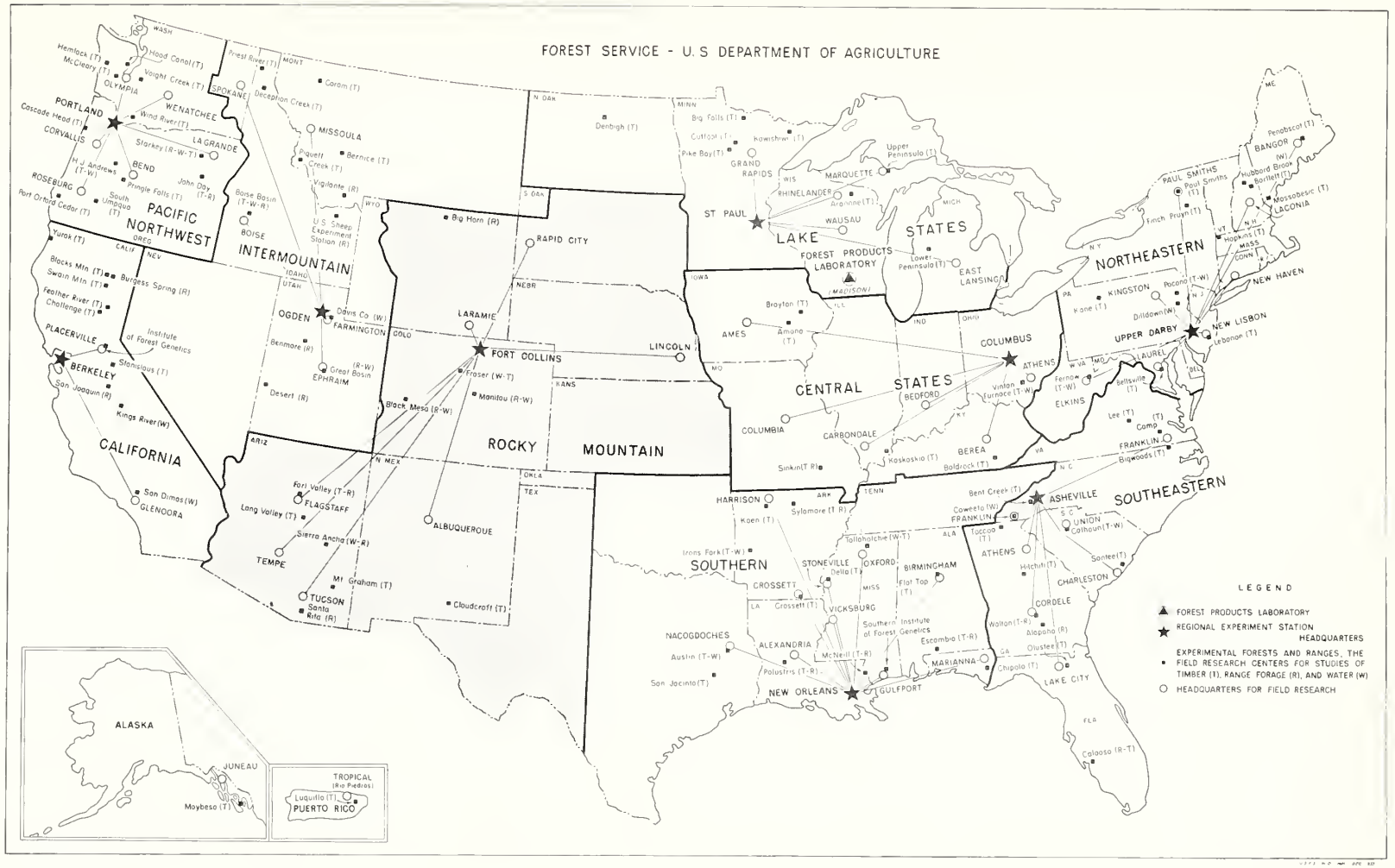
A resume of water-yield studies underway in the central Rocky Mountains, in four broad zones or vegetation types: (1) above timberline; (2) timber zone with two phases, (a) spruce-fir-lodgepole pine, and (b) mixed conifers; (3) woodland-brush zone; and (4) stream bottoms.

Rich, Lowell R., and Reynolds, Hudson G.
Grazing in relation to runoff and erosion on some chaparral watersheds of central Arizona. Jour. Range Mangt. 16: 322-326, illus.

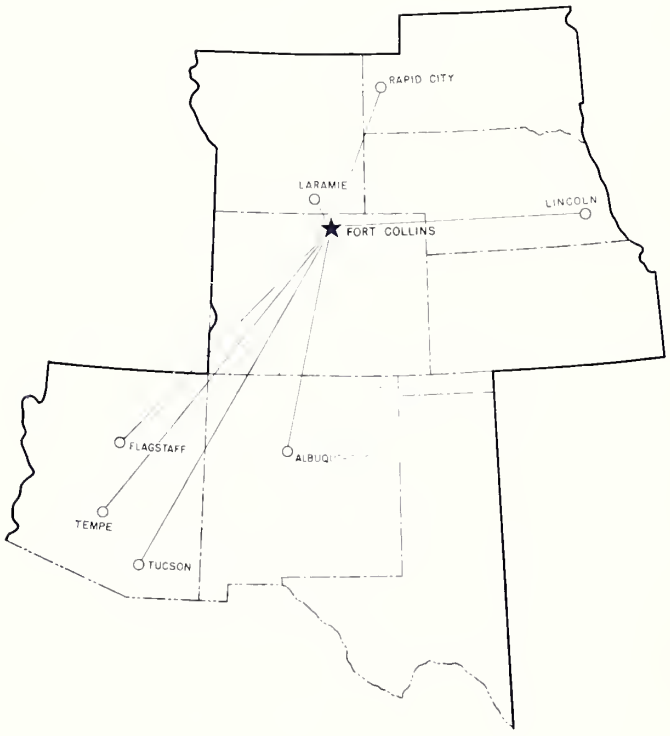
Grazing treatments on four watersheds (9 to 19 acres) indicated no significant difference in water yield. One watershed was grazed to 80 percent use perennial grasses, one to 40 percent, and two were not grazed. Sediment yields averaged 17 to 132 tons per square mile per year--comparatively low.

Skau, C. M., and Swanson, R. H.
An improved heat pulse velocity meter as an indicator of sap speed and transpiration. Jour. Geophys. Res. 68: 4743-4749, illus.

Improved instrument is stable from -50° to 80° C. Multipoint and continuous sampling are feasible modifications. V is closely related to volume flow through stems and vapor loss from tent-enclosed trees. Effects of light, irrigation, soil drying, and leaf wetting on V agree with accepted concepts.



Location of the Forest and Range Experiment Stations and the Forest Products Laboratory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